APM Conceptual Design and Cost Estimate Update
Transportation Design Report

APM-REP-00440-0005 **August 2011**

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NUCLEAR WASTE MANAGEMENT ORGANIZATION
SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

NWMO
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TRANSPORTATION DESIGN REPORT

Submission to

Nuclear Waste Management Organization

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Title

Report
Transportation Design

Project

APM Conceptual Design and Cost Estimate Update

CLIENT: NUCLEAR WASTE MANAGEMENT ORGANIZATION

PROJECT: APM Conceptual Design and Cost Estimate Update

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EXECUTIVE SUMMARY

The Nuclear Waste Management Organization (NWMO) is implementing Adaptive Phased Management (APM), Canada's plan for the long-term management of used nuclear fuel. The APM approach encompasses centralized containment and isolation of the used fuel in a Deep Geological Repository (DGR) in a suitable rock formation, such as crystalline rock or sedimentary rock.

In 2009, the NWMO undertook the task to update previously completed conceptual design work related to the APM program. This report on Transportation Design addresses concepts for the used fuel packaging and loading systems and the associated transportation procedures.

Two used CANDU fuel inventory scenarios are considered in this transportation analysis: 3.6 million used fuel bundles (Base Case) and 7.2 million used fuel bundles (Alternate Case), as detailed below. A rate of delivery of 120,000 bundles per year for both scenarios has been selected to match the overall operating capacity of the DGR facility.

Used CANDU Fuel Quantities (as Bundles) by Owner

Owner	Base Case	Alternate Case
Ontario Power Generation	3,272,140	6,567,228
AECL	30,715	30,715
Hydro-Québec	132,838	272,000
New Brunswick Power	121,758	285,000
TOTAL (rounded)	**3,600,000**	**7,200,000**

From: Used Nuclear Fuel Inventory and Transportation Estimates, NWMO TR-2009-21

The transportation program is assumed to be operational for either 30 years (Base Case), or 60 years (Alternate Case). The mode of transportation is assumed to be by road to a DGR located somewhere in Ontario.

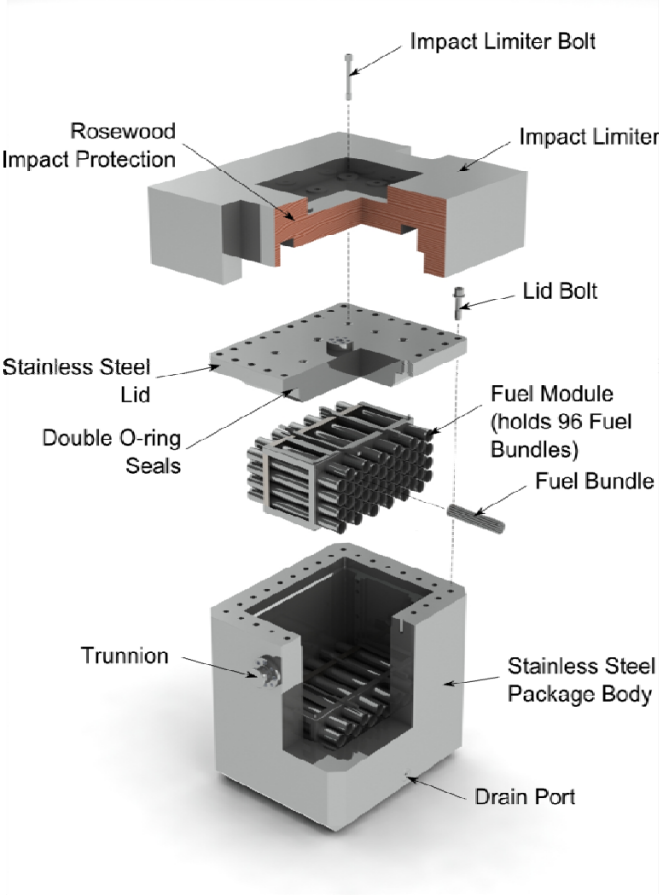
The Base Case and Alternate Case scenarios are very similar with respect to the core methods and equipment presented for the used fuel transportation system. There are slightly larger equipment fleet sizes required for the Alternate Case which assumes (in part) the construction of new reactor facilities. In addition, the longer duration of the Alternate Case necessitates additional equipment replacement events.

Prior to transportation to the DGR, the used fuel will be transferred into a certified road transportation cask (an Irradiated Fuel Transport Cask or IFTC) at the reactor storage site. Used fuel placed in the IFTCs will be in modules.

Each IFTC will be used to transport two used fuel modules. Each module will hold 96 used fuel bundles.

The dry storage transfer methods employed will be based on existing procedures currently in operation at storage facilities. These methods have been developed over the years as safe and reliable techniques for the transfer of used fuel.

For most reactor sites, the construction of new transfer facilities will be required including a Hot Cell, shipping area and transport loading facility under one building. Such facilities will be required at Ontario Power Generation's Pickering, Bruce and Darlington sites, the Gentilly operations under the jurisdiction of Hydro-Québec and AECL, and New Brunswick Power's Point Lepreau reactor. The approach to be employed at AECL's Chalk River and Whiteshell facilities, considering the small quantity of used fuel stored at these locations, requires further study. It is assumed that existing infrastructure will be sufficient to accommodate the limited number of transfer operations. AECL's used fuel inventory at Douglas Point is assumed to be transferred through OPG's Bruce operations.



Irradiated Fuel Transport Cask or IFTC

Where the Hot Cell approach is followed, a new building will need to be constructed at the reactor storage sites to house the transfer and shipment functions.

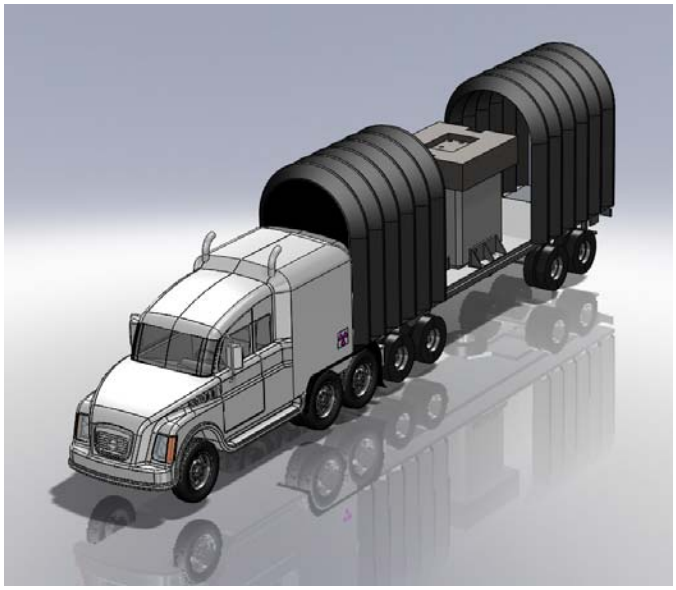
The current Canadian Nuclear Safety Commission (CNSC) regulations classify the CANDU used fuel as a Category II nuclear material for security purposes. They further consider the IFTC to be a Type B radioactive materials transportation package (intended to provide sufficient shielding and protection for workers and the general public while also containing the radioactivity and dissipating the heat generated by the used fuel). The selected used fuel transportation system equipment as well as the system's logistics, security and safety protocols have been influenced by these regulations and associated guidance.

For example, the identified material transportation logistics will minimize the in-transit labour hours and eliminate the need for secure overnight stopovers for shipments by recognizing and making use of (in part) on-board tractor sleeping berths to accommodate alternate driving/ security teams. Regulatory guidance states that shipments of Category II nuclear material should be accompanied by one or more escorts, such as nuclear security guards. These

escorts should maintain constant surveillance of the shipment by traveling in the cargo vehicle or in an accompanying vehicle. Additional transportation vehicles will be available at the reactor storage sites and the DGR to provide for efficient transport team receiving and dispatching functions.

As illustrated, the transportation vehicle system will be comprised of:

- Transportation Vehicle (tractor and trailer); and
- IFTC (filled or empty) with impact limiter.



Transportation System with IFTC - Weather Cover Open

Real-time tracking systems that incorporate multiple forms of built-in redundancy based on secure, encrypted satellite technology will be in place. Emergency response capabilities will feature back-up vehicles and equipment at the DGR and strategic reactor storage sites as well as a heavy duty portable crane system located at the DGR.

As presented in this report, the shipment of used fuel by road to the DGR is realistic and achievable using currently available technology. The safety of loading the nuclear material into the IFTC and transporting it to the DGR is well served by the design intentions discussed herein. The identified used fuel transportation system encompassing the loading equipment, vehicles, routes, logistics, monitoring and on-route support to move used fuel by road from the existing reactor storage sites to the DGR will maintain a high level of safety and security and minimize the time that the used fuel is in transit.

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DEFINITIONS AND ACRONYMS

The major terms used in this document are described below:

AECL means Atomic Energy of Canada Limited; a federal crown corporation.

APM means Adaptive Phased Management, a management system based on phased and adaptive decision-making supported by public engagement and continuous learning.

Basket is a sealed container designed to maintain the geometry of a used fuel bundle arrangement inside a cask, silo or vault. Of varying designs, the baskets hold from 38 to 60 fuel bundles vertically in circular rings.

Cask or Flask is a mobile durable container for enclosing and handling used fuel for storage or transport. The cask wall shields radiation and heat is transferred by conduction through the wall.

DGR means Deep Geological Repository. The physical system intended for the long term management of used CANDU nuclear fuel.

GPS means global positioning system.

GVW or Gross Vehicle Weight is the total weight of a vehicle (tractor, trailer and the load).

Hot Cell is an isolated shielded room that provides a controlled environment for containing highly radioactive and contaminated material and equipment.

HQ means Hydro Québec, a crown corporation for electricity generation in the province of Québec.

IFTC is an Irradiated Fuel Transport Cask used to transport used fuel from the reactor storage facilities to the DGR.

IFTC/M is an IFTC filled with used fuel modules.

Module is a rack system for holding used fuel bundles. One module contains 96 bundles within horizontal tubes in a rectangular framework.

NBP means New Brunswick Power, a crown corporation for electricity generation in the province of New Brunswick.

NWMO means Nuclear Waste Management Organization.

OPG means Ontario Power Generation, a crown corporation for electricity generation in the province of Ontario.

Owners collectively means the current parties responsible for the used fuel inventories; Ontario Power Generation, AECL, Hydro-Québec and New Brunswick Power.

Pre-loaded is when a driver is not present at the time of loading the IFTC transport trailer. The load is prepared in advance of sending the driver in to pick it up.

Tare Weight is the weight of an empty truck or trailer, without occupants or loads.

Tractor means the motive vehicle of the IFTC transportation vehicle system that pulls the trailer.

UFPP means used fuel packaging plant.

UFTS means used fuel transportation system; the loading equipment, vehicles, routes, logistics, monitoring, labour and on-route support to package and move used fuel by road from existing reactor storage sites to the DGR.

Used Fuel (or used nuclear fuel) means the CANDU irradiated fuel bundles removed from a CANDU nuclear fission reactor. Used fuel is initially held for a minimum 30 year period at the reactor facilities prior to handling in the UFTS,

1. INTRODUCTION

The Nuclear Waste Management Organization (NWMO) is implementing Adaptive Phased Management (APM), Canada's plan for the long-term management of its used nuclear fuel. The APM approach encompasses centralized containment and isolation of the used fuel in a Deep Geological Repository (DGR) in a suitable rock formation, such as crystalline rock or sedimentary rock.

In 2009, the NWMO undertook the task to update the previous conceptual design related to the APM program. This report on Transportation Design is meant to address concepts for the used fuel packaging and transport cask loading system and the used fuel transportation system. Under the APM initiative, the used nuclear fuel is to be retrieved from interim storage facilities at the (reactor) Owners' storage locations and then transferred into transportation casks. The casks, loaded onto transport trailers, are to be transported by road to the DGR.

Two used nuclear fuel inventory scenarios are considered in this transportation analysis. Under the Base Case, 3.6 million used fuel bundles will be directed to the DGR over a 30 year placement period. The Alternate Case, which assumes (in part) the construction of new nuclear reactors, sees this quantity increased to 7.2 million bundles delivered to the DGR over a 60 year period.

Subsequent sections of this report address the current and projected used fuel inventory to be managed (Section 3) and the certified Irradiated Fuel Transport Cask or IFTC intended for the fuel shipment (Section 4). Section 5 addresses the transfer of used fuel to the IFTC and Section 6 discusses the expected rate of used fuel shipments to the DGR. Required transportation equipment is dealt with in Section 7 and Section 8 reviews the IFTC loading and unloading procedures for the utilized transport trailers. Sections 9 and 10 provide an overview of the anticipated transportation logistics and maintenance and inspection requirements. Sections 11 and 12 deal with safety and security issues as well as emergency response.

As noted herein, the entire used fuel transportation system (UFTS) encompasses the loading equipment, vehicles, routes, logistics, monitoring, labour, on-route package support and transport of the used fuel from the reactor storage facilities to the DGR.

2. SCOPE AND ASSUMPTIONS

The following sections identify the main assumptions and design criteria that formed the starting basis for the transportation analysis contained in this document. Battery limits (the scope of analysis) are also discussed.

2.1 Design Requirements

Various regulations, codes and standards were referenced in the completion of the supporting project work to this report. The primary of such references, which included both domestic and international sources, included the following:

- Packaging and Transport of Nuclear Substances Regulations, SOR/2000 208 31 May 2000, plus amendments SOR/2003-405;
- Nuclear Security Regulations, SOR/2000-209 plus amendments SOR/2006-191;
- CNSC's Regulatory Guide G-208 Transportation Security Plans for Category I, II or III Nuclear Material, March 2003 Transport Canada;
- Transportation of Dangerous Goods Regulations, including Amendment 6, SOR/2008-34, February 20, 2008;
- Commercial Vehicle Drivers Hours of Service Regulations, SOR/2005-313;
- IAEA Safety Standards Series, Regulations for the Safe Transport of Radioactive Material, 1996 Edition (Revised), No. TS-R-1 (ST-1, Revised); and
- Radiation Protection Regulations, Registration SOR/2000-203, 31 May 2000, Canada Gazette Part II, Vol 134, No. 13, 21st June 2000.

2.2 Assumptions

The primary assumptions that formed the basis for the transportation analyses included the following:

- All used fuel is in the form of CANDU fuel bundles, with dimensions of 102.5 mm OD x 495 mm to 508 mm long. The bundles themselves are contained in modules for transport purposes. The small quantities of non-CANDU fuel held by AECL are excluded from the scope of this study and may require additional considerations for transport;

- All fuel is assumed to be dry and in modules ready for loading into an IFTC at a hot cell facility. Operational optimization may differ from from this assumption;

- Two discrete used fuel inventory scenarios are to be examined, the Base Case and Alternate Case comprising 3.6 million and 7.2 million used CANDU fuel bundles, respectively. Note that these are NWMO assumptions for the purposes of the APM reference design and cost estimate update and may differ from current waste owner operational forecasts;

- Used fuel bundles will originate from facilities under the control of Ontario Power Generation (Pickering, Darlington and Bruce), AECL (Douglas Point, Chalk River, Whiteshell and Gentilly 1), Hydro-Québec (Gentilly 2), and New Brunswick Power (Point Lepreau);

- Further, under the Alternate Case, two additional multi-unit reactor sites (New Build A and New Build B) are assumed to have been established in Ontario;

- The used fuel modules are to be carried within IFTCs to the DGR;

- IFTCs will be re-used for multiple trips, modules will only be used once. A design life of 30 years for the IFTC is achievable with routine maintenance of the wearable components (e.g., bolts, gaskets, etc.);

- The design and certification of the IFTC is excluded from the scope of this work;

- A rate of delivery of 120,000 bundles per year for both scenarios has been selected to match the overall operating capacity of the DGR facility;

- The mode of transportation to the DGR is assumed to be by road. Road upgrades are not expected to be necessary;

- While a location for the DGR has not yet been chosen, for the purposes of assessing transportation logistics it is assumed to be in Ontario and 1,000 km from all Ontario-based reactor storage sites (including the potential New Build A and New Build B facilities) as well as from the Whiteshell operations. It is also assumed to be 1,500 km from the Gentilly facilities and 2,500 km from Point Lepreau;

- All used fuel is to be 30 years out of the reactor prior to shipment;

- Used fuel transport to the DGR will commence in the first year of the DGR's operation for OPG owned fuel and 15 years later for non-OPG owned fuel;

- Used fuel shipments will occur over 30 years under the Base Case and 60 years under the Alternate Case;

- All Owners' reactor storage sites will have sufficient real estate for the construction and operation of any building required for loading or shipping facilities. The potential re-use of existing buildings to accommodate these facilities might also be considered by the site Owners; and

- On-board tractor sleeping berths will be used to accommodate alternate driving/security teams to avoid the need for regular overnight stopovers during used fuel transports.

2.3 Battery Limits

The scope of analysis of the Transportation Design Report spans the collection and loading of the CANDU used fuel at the reactor storage sites and its transportation to the DGR (for receipt at that facility's Used Fuel Packaging Plant).

At the used fuel storage sites it is assumed that the reactor Owner has already completed any installations and made operational any equipment required to retrieve and re-package the used fuel into modules in preparation for loading into an IFTC. This includes any efforts needed to be directed towards retrieving the used fuel from irradiated fuel bays or from dry storage and placing it into a suitable IFTC loading location.

The battery limit interface for the transportation system at the DGR will be at the Used Fuel Packaging Plant (UFPP). Equipment and facilities available in the UFPP (outside the scope of this Report) will be used to extract the used fuel modules from the IFTCs and to subsequently process the used fuel bundles. Maintenance of the IFTCs will take place at the DGR site.

3. USED FUEL INVENTORY

Used fuel to be managed at the Deep Geological Repository is assumed to originate from 22 CANDU commercial power reactors in Canada, 20 of which are situated in Ontario with additional locations in Québec and in New Brunswick. The main reactors in Ontario, owned by Ontario Power Generation (OPG), are located on the Pickering, Bruce and Darlington sites. The reactor near Bécancour, Québec (Gentilly 2), is owned by Hydro-Québec and the Point Lepreau reactor in New Brunswick is owned by New Brunswick Power.

In addition to these commercial power reactors, there are also four partially decommissioned demonstration/research reactors identified as Chalk River, Douglas Point, Gentilly 1 and Whiteshell. These operations are under the jurisdiction of AECL.

Figure 1 shows the reactor site used fuel storage locations (Appendix A provides further location-specific information for each facility). It should be noted that, due to their close proximities, the Douglas Point used fuel inventory is assumed to be managed through the Bruce facility and the Gentilly 1 used fuel inventory is expected to be managed through the Gentilly 2 facility.

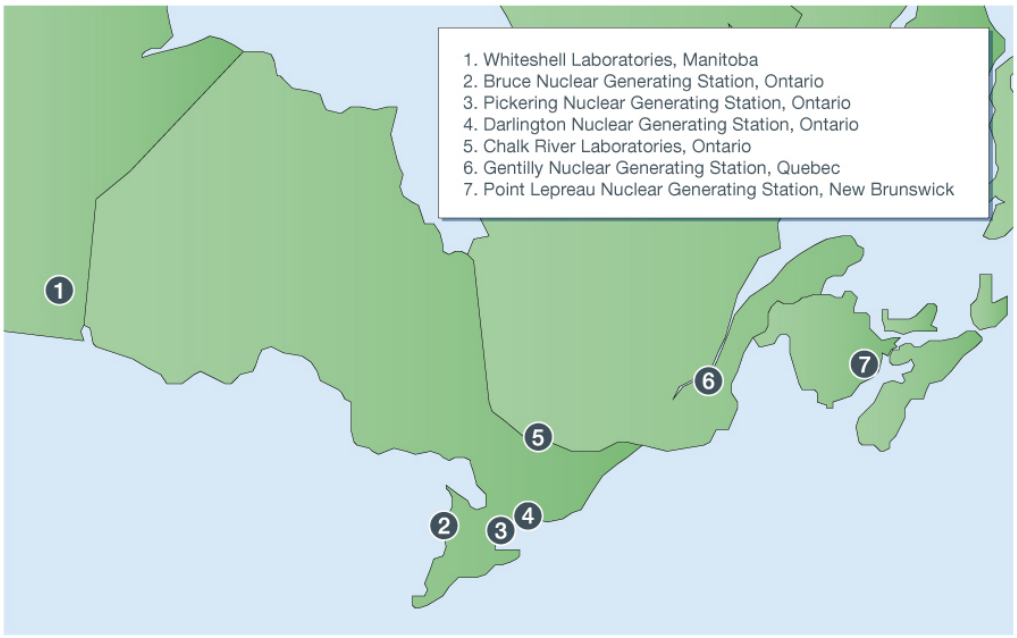


Figure 1: Used Fuel Storage Facility Locations

All of the used nuclear fuel material from these locations will be received at the DGR. In addition, under the Alternate Case, two new reactor sites are also assumed to have been established with generated used fuel requiring management at the DGR. Anticipated to be based on existing reactor designs with shipping, receiving and storage facilities similar to that

in-place at other OPG reactor sites, the New Build A and New Build B power plants are assumed to be 1,000 km away from the DGR.

3.1 Used Fuel Classification

An important assumption for the current work is the classification of CANDU used fuel. This material is considered a Category II nuclear material for security purposes. As discussed later in Sections 7, 9, 10, 11 and 12, this classification is associated with several issues of security logistics and security requirements.

Further, CANDU used fuel has a Dangerous Goods Classification of Class 7 - Radioactive Material (a classification that is applied regardless of the degree of chemical or radiological hazard). This is important for determining marking and labelling requirements for shipments.

3.2 Used Fuel Bundles and Modules

The used fuel itself is presented in a used fuel bundle. After discharge from the reactor the bundles are initially stored under water in licensed wet bays at the reactor sites. Thereafter, subsequent to a minimum cooling duration, the bundles can be transferred into dry storage containers (Note: all used fuel from the reactor storage facilities is assumed to be 30 years out of the reactor prior to shipment to the DGR). While dry storage is being increasingly practiced at all storage locations, both wet and dry storage practices for the used fuel are encountered at the various reactor facilities. A typical CANDU fuel bundle is shown in Figure 2.

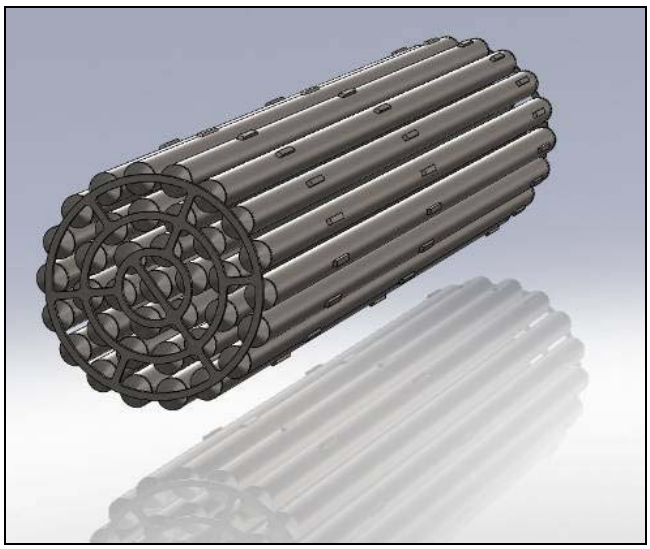


Figure 2: Used Fuel Bundle

The bundles are to be transported to the DGR in storage modules. A module is a rack system for holding the fuel bundles as currently used by OPG for the storage of used fuel in wet bays

and in dry storage containers. 96 fuel bundles are stored in linear pairs in horizontal tubes held in a rectangular framework. A typical module with used fuel bundles, which weighs approximately 2,500 kg, is shown in Figure 3.

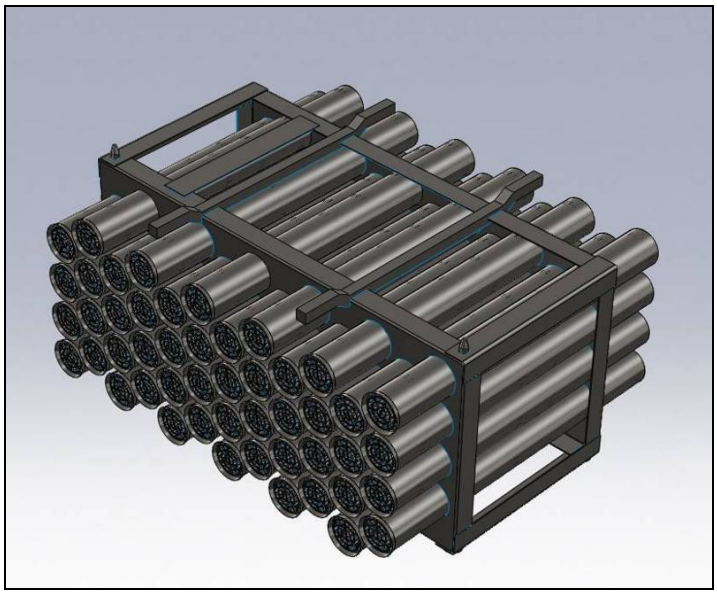


Figure 3: Used Fuel Module

3.3 Used Fuel Quantities

Quantities of used fuel assumed to be generated by each Owner are listed in Table 1. The specific generation sites and their anticipated total transportation amounts (reported as used fuel bundles) are provided on Table 2. As evident, quantities are presented for the Base Case (existing situation) as well as the Alternate Case, which assumes the future commissioning of two new reactor sites in Ontario.

Table 1: CANDU Used Fuel Quantities (as Bundles) by Owner

Owner	Base Case	Alternate Case
Ontario Power Generation	3,272,140	6,567,228
AECL	30,715	30,715
Hydro-Québec	132,838	272,000
New Brunswick Power	121,758	285,000
TOTAL (rounded)	**3,600,000**	**7,200,000**

From: Used Nuclear Fuel Inventory and Transportation Estimates, NWMO TR-2009-21

Table 2: CANDU Used Fuel Quantities (as Bundles) by Site

Site	Base Case		Alternate Case	
	Bundles	% of Total	Bundles	% of Total
Pickering	856,113	24.1	1,235,943	17.3
Darlington	891,482	25.1	1,332,037	18.6
Bruce	1,524,545	42.9	2,340,197	32.7
Douglas Point	22,256	0.6	22,256	0.3
Chalk River	4,886	0.1	4,886	<0.1
Whiteshell	360	<0.1	360	<0.1
Gentilly 1	3,213	0.1	3,213	<0.1
Gentilly 2	132,838	3.7	272,000	3.8
Point Lepreau	121,758	3.4	285,000	4
New Build A			807,738	11.3
New Build B			851,313	11.9
Total (rounded)	3,600,000	100	7,200,000	100

4. IRRADIATED FUEL TRANSPORT CASK (IFTC)

In the mid 1980s, OPG developed a certified used fuel transport cask known as the Irradiated Fuel Transport Cask (IFTC) specifically for road transportation. The IFTC is shown in Figure 4.

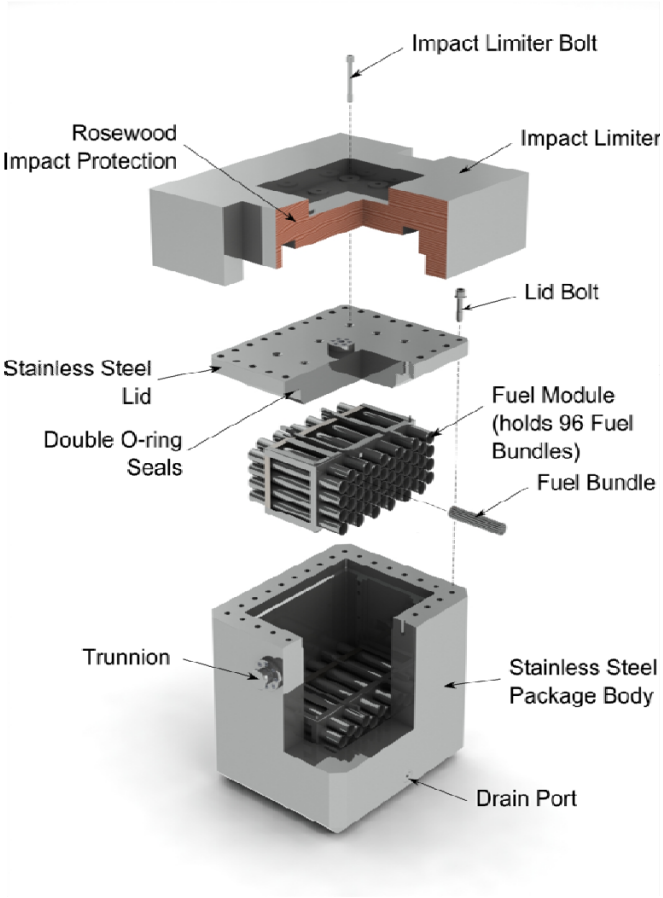


Figure 4: IFTC

The casks are designed to be constructed with stainless steel for its impact strength, ductility, shielding properties and relative ease of decontamination. The lid is bolted on with 32 heavy duty stainless steel bolts and sealed with two “O” rings. The cask is designed to absorb lateral force through the cask walls, and not through the lid, to minimize the chance of the bolts shearing and to keep the lid from separating.

The impact limiter is made out of rosewood and covered with stainless steel to fit over the lid to protect it and the bolts from impact and fire. Rosewood was selected because of its energy absorbing and insulation properties and its ability to resist combustion.

Two trunnions are located on the cask sides for lifting and tie-down during transportation. The vents and drain on the cask are sealed with 'O' rings.

The IFTC is certified under the Canadian Nuclear Safety Commission's Packaging and Transport of Nuclear Substances Regulations as a Type B radioactive materials transportation package. Type B packages are intended to provide sufficient shielding and protection for workers and the general public while also containing the radioactivity and dissipating the heat generated by the used fuel. Type B packages must be demonstrated to meet routine, normal and accident conditions of transport through a series of performance tests which include:

- A 9 m drop onto an unyielding (very hard) surface;
- A 1 m fall onto a steel pin or spike;
- A fully engulfing 800°C fire for 30 minutes; and
- Immersion in 15 m of water for 8 hours.

The filled cask must also remain within road transport weight limits. Specific labelling is required for both the package and vehicle(s).

4.1 IFTC Capacity

The IFTC will be able to transport 192 bundles of used fuel in two modules (i.e., 96 used fuel bundles per module).

When empty, the cask will be referred to as an IFTC. When filled with used fuel, it will be referred to as an IFTC/M (that is, an IFTC with modules).

4.2 Weight and Dimensions

The rectangular, stainless steel cask measures 1.6 m x 1.9 m x 1.8 m (width, length, height). With the impact limiter in place, these dimensions increase to 2 m x 2.3 m x 2.2 m, respectively. The wall thickness of the cask is approximately 270 mm and the weight when full is about 35 tonnes. The IFTC has the approximate weight as shown on Table 3.

Table 3: IFTC Weights

Description	Weight
Empty IFTC	~29,500 kg
Used Fuel (2 Modules)	~5,200 kg
Filled IFTC/M	~34,700 kg

Loading and handling features of the IFTC are illustrated below as Figure 5.

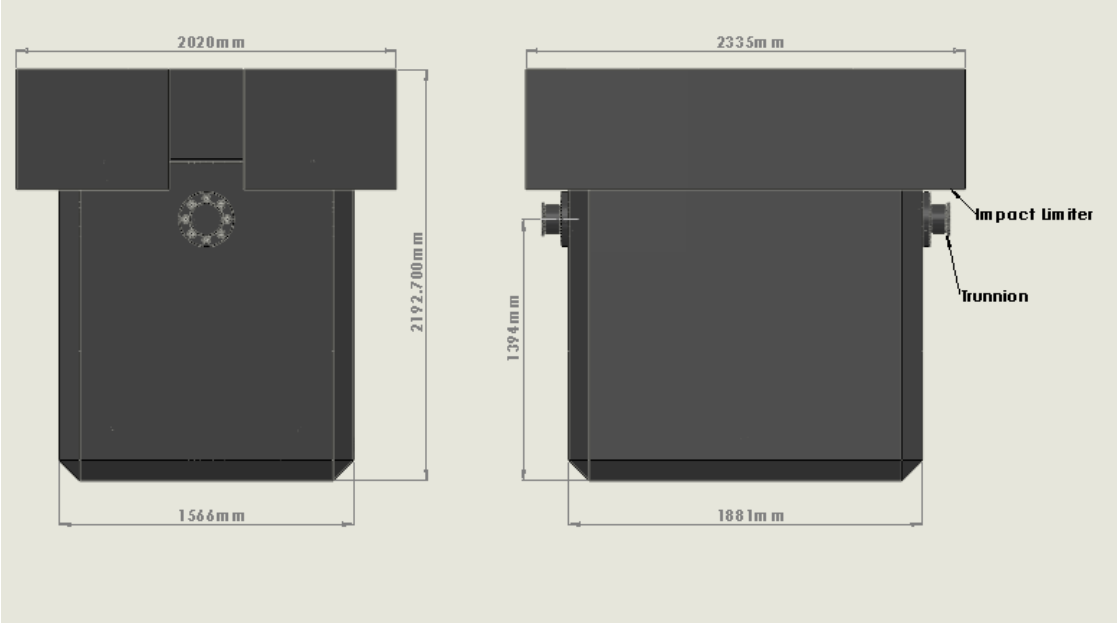


Figure 5: Loading and Handling Features of IFTC

Given the uniform nature of the fuel bundles inside a module, the centre of gravity (COG) of a filled IFTC/M will be approximately located at the geometric centre of the cask as shown in Figure 6.

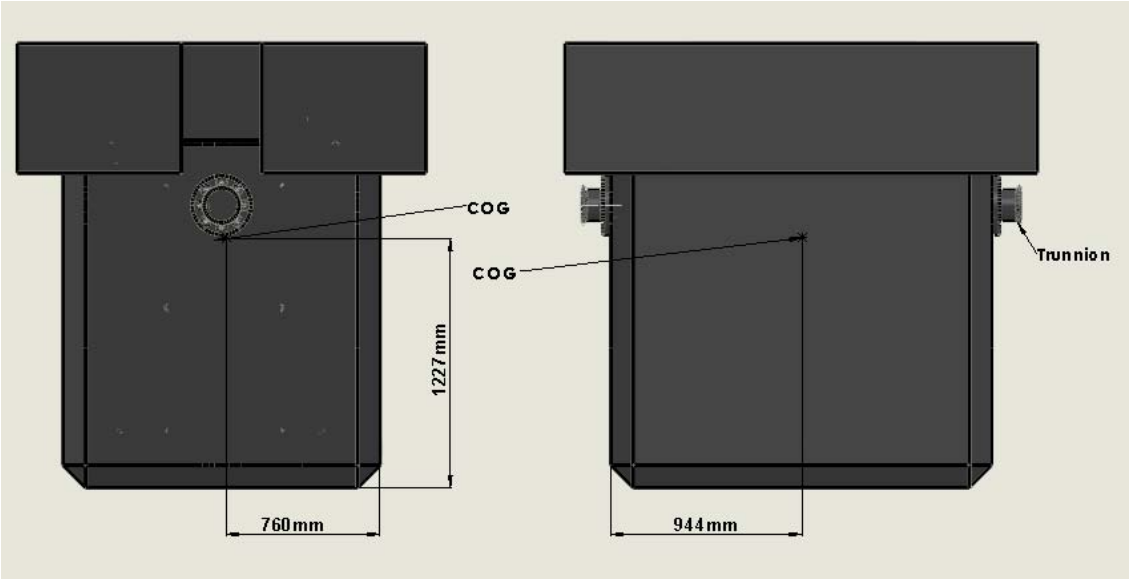


Figure 6: IFTC/M Transport Cask Expected Centre of Gravity

4.3 Maintenance and Replacement

Regular care of the IFTCs and impact limiters will be performed at a maintenance facility located at the DGR. Regular maintenance may include:

- Decontamination of cask cavity, external shell and lid;
- Inspection of the outside integrity (welds, scrapes, dents, etc.);
- Inspection of the inside integrity (welds, scrapes, dents, etc.);
- Inspection/repair of the trunnions and other lifting/securing points;
- Inspection/replacement of the threaded bolts that secure the lid; and
- Inspection and testing of the seals that support radiological containment.

It is assumed that an IFTC will be fully inspected / maintained every 10th shipment to the DGR and that approximately 5% of the availability time for the IFTCs will be consumed by such activities each year. Each maintenance schedule will take approximately 5 days. In addition to regular maintenance of the IFTC, a 30 year replacement interval is anticipated. Each IFTC will have a unique identification number permitting full traceability.

To ensure maximum efficiency and to account for unexpected events, two additional IFTCs - beyond those required for ongoing transportation and loading operations - should be available to the used fuel transportation system.

4.4 Inventory Control and Number of Shipments

The IFTC fuel loading system will combine elements of both push and pull inventory systems. With regards to the former, the delivery of newly filled IFTC/Ms to the specified shipment storage areas at the reactor sites is a form of push style inventory control. Pull inventory control is evidenced when empty IFTCs are removed from their respective storage areas.

With consideration for the estimated time durations for all tasks expected in the loading and transfer operations, the anticipated used fuel shipments for the Base Case and Alternate Case are shown below in Table 4. Shipment periods are expressed in years (Y) of APM implementation.

Table 4: CANDU Used Fuel Shipments

Owner	Sites	Base Case		Alternate Case	
		Period (year) of Shipments	Total Shipments	Period (year) of Shipments	Total Shipments
OPG	Pickering	Y26 - Y55	4,461	Y26 - Y66	6,440
	Darlington	Y26 - Y55	4,644	Y26 - Y69	6,939
	Bruce	Y26 - Y55	7,942	Y26 - Y77	12,191
AECL	Douglas Point	Y41 - Y51	124	Y41 - Y51	124
	Chalk River	Y52 - Y55	27	Y51 - Y55	27
	Whiteshell	Y51	2	Y51	2

Owner	Sites	Base Case		Alternate Case	
		Period (year) of Shipments	Total Shipments	Period (year) of Shipments	Total Shipments
	Gentilly 1	Y52 - Y55	18	Y51 - Y55	18
HQ	Gentilly 2	Y41 - Y55	697	Y41 - Y72	1,417
NBP	Point Lepreau	Y41 - Y55	636	Y41 - Y74	1,486
OPG	New Build A	NA	NA	Y67 - Y85	4,208
	New Build B	NA	NA	Y66 - Y85	4,435
			18,551		**37,287**

4.5 Number of IFTCs Required

The optimum number of IFTCs to ensure the smooth and efficient transfer of modules from the reactor storage sites to the DGR is dictated by annual loading, maintenance and shipping requirements. In particular, the IFTC shipments per year need to be balanced to accommodate the targeted processing capacity at the DGR's Used Fuel Processing Plant. While reactor storage site-specific peak yearly shipments will occur during the anticipated annual transportation schedules, the number of IFTC shipments to the DGR is expected to average 630 per year.

In addition to the IFTCs required for loading, maintenance and shipping activities, one additional unit will be built for testing and mock-up with interfacing equipment. Table 5 shows the IFTC quantities with the maintenance allowance included.

Table 5: Estimated Quantity of IFTCs Required

System	Quantity	
	Base Case	Alternate Case
Transportation	18	21
Loading	4	6
Cask Maintenance	2	2
Mock-up	1	1
Total	**25**	**30**

As illustrated above, the total number of IFTCs required for the Base Case is 25 whereas 30 are needed for the Alternate Case. The higher quantities for the Alternate Case are primarily due to the addition of the two new build reactor sites and their corresponding peak yearly shipment quantities. For training and commissioning at the reactor storage sites, a small number of IFTCs should be ordered prior to implementation of the used fuel transportation system.

5. TRANSFER OF USED FUEL TO IFTC

A dry storage transfer approach will be used to load the used fuel (in modules) into the IFTC at the reactor storage facilities. The Hot Cell transfer approach is assumed to be undertaken at the five production reactor sites and the two new build sites. The transfer approach for the limited amount of used fuel at the research sites (Whiteshell and Chalk River) has not yet been determined, but will likely be based on available facilities and be similar to the Hot Cell Transfer approach.

The high level steps in the Hot Cell transfer approach are as follows:

Hot Cell Transfer

- IFTC impact limiter removed
- IFTC extracted from secure storage and transferred to loading area
- IFTC and owner's cask placed in Hot Cell and lids removed
- IFTC loaded with modules from owner's cask
- IFTC/M lid re-installed
- IFTC/M removed from Hot Cell
- Decontamination
- Air pressure decay test
- IFTC/M inspection
- Transfer to secure storage area
- Installation of Impact Limiter and Security Seals

The ready-to-ship IFTC/M is then transferred to a secure holding area to await transport to the DGR.

5.1 Hot Cell Transfer

As previously noted, in order for a safe and reliable method of transferring used fuel (in modules) from an Owner's cask into the IFTC, the construction of Hot Cells is required at specific reactor storage sites. They provide suitably shielded work environments for the protection of operators with features such as lead glass windows and remote manipulators and/or robotics to inspect and handle the irradiated material (the used fuel).

The exact use of Hot Cells may vary by reactor storage site depending upon the type of infrastructure present at the site and the quantities of used fuel to be transferred. The assumed method to be employed at each site is indicated below in Table 6.

Table 6: Used Fuel Transfer Approach by Reactor Storage Site

Reactor Storage Facilities	Used Fuel Transfer Approach
Pickering	Hot Cell at Pickering Used Fuel Dry Storage Facility
Darlington	Hot Cell at Darlington Used Fuel Dry Storage Facility
Bruce	Hot Cell at Western Used Fuel Dry Storage Facility (shared facility)
Douglas Point	
Chalk River	Requires more detailed investigation
Whiteshell	Requires more detailed investigation
Gentilly 1	Hot Cell (shared facility)
Gentilly 2	
Point Lepreau	Hot Cell
New Build A	Hot Cell
New Build B	Hot Cell

5.1.1 Design Considerations

The Hot Cell design for the transfer of used fuel is influenced by a number of factors including the provision of adequate shielding, the provision of a safe working environment and the minimization or elimination of cross or external contamination of equipment and casks during operations. Integrated design considerations are described in Table 7, as follows.

Table 7: Hot Cell Design Considerations

Design Considerations	Description
Radiation Shielding	The Hot Cell will be constructed of high density concrete for its enhanced shielding properties. Shielded windows will be in place to allow operators to view the equipment and used fuel transfer. Access doors for general repair and maintenance work will also be shielded and shielding will further be integrated into the cover of the Hot Cell pit to eliminate possible radiation streaming from the dry docking procedures. Finally, the atmosphere in the Hot Cell will be kept at a negative differential pressure with respect to the surrounding operating areas.
Movement and Manipulation of Casks	Hoists/cranes and lifting beams will be installed to open or close the cask lids and transfer used fuel into an IFTC using carriage mounted manipulator/grippers. A shuttle will also be used to position the casks in the Hot Cell and cask lifts will be integrated in the design to lift the casks to the Hot Cell gate (in preparation for fuel transfer). The shuttle, which is fixed to the ground, is dedicated to the lateral transfer of the IFTC between the Hot Cell docking gate and the loading pit. Locking mechanisms will ensure the safe positioning of the casks.

Remote Control of Hot Cell Systems	A radiation-hardened video camera system with a viewing scope covering the crane hooks, grippers, used fuel movement, etc. will be installed in the Hot Cell. Remote control of the equipment, including cranes and master slave manipulators will be permitted by the installed equipment.
Control of Cross or External Contamination	The Owner's cask and IFTC will initially be dry docked to reduce the potential for external contamination (to only the cask lids and general outer shell area around the lids). This will reduce the time spent on decontamination and the volumes of secondary wastes generated during such activity. Separate rolling equipment or carts will not be used to enter or exit a Hot Cell or place cask(s) in loading areas. The Hot Cell interiors will be lined with stainless steel to aid in cleanup and decontamination.

5.1.2 Configuration and Design Dimensions

The size of the Hot Cell is determined considering the dimensions of the IFTC, the space required for cask lid placement as well as the accommodation of hoists, docking gates and equipment (e.g., lifting beams) for the safe transfer of the used fuel. Its height is governed by the gantry crane lifting height and the potential incorporation of a loading pit for casks. A loading pit can lower the casks to a height where the lids are approximately at the operators' waist level to facilitate decontamination activities. The length of the Hot Cell is set by the widths of the casks and their removed lids (during the transfer process). Consideration would also be made in this respect to minimizing the travel distances from the Owner's cask to the IFTC. Removed lids will be placed over the docking gates on a rack to further reduce the overall Hot Cell length.

With further consideration for clearance allowances, shielding wall thicknesses, etc. the overall dimensions of the Hot Cell will be 15 m x 6 m x 7 m (length x depth x height). The length and height should be sufficient to fit within a standard industrial building at the reactor storage sites assuming that the building height is at least 8.5 m. It is anticipated that new buildings will need to be constructed at the storage sites for this purpose.

A concept hot cell is shown in Figure 7.

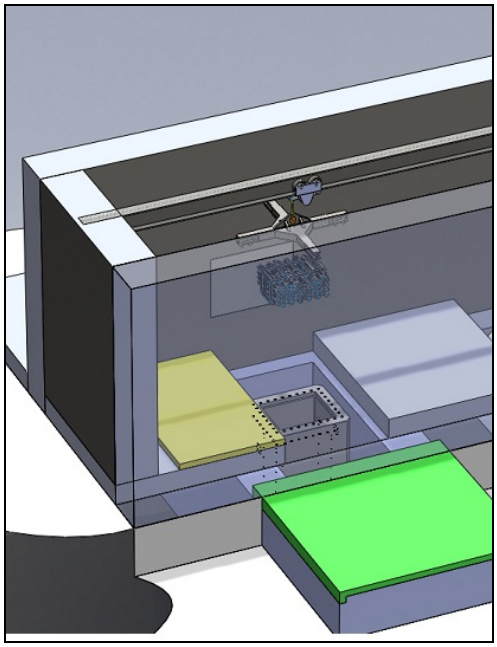


Figure 7: Hot Cell with Fuel Module being Transferred

5.1.3 Sequencing of Operations

The sequencing of operations will typically include the preparation of the casks, used fuel placement and IFTC/M transfer to the shipment areas. In particular, and as illustrated on Figures 8 and 9, the sequence includes:

Preparation of IFTC and Transfer to Hot Cell

- Impact limiter removed from IFTC in secure storage;
- Transfer IFTC from storage area to Hot Cell loading pit;
- Remove IFTC lid bolts;
- IFTC transfer under Hot Cell docking gate;
- IFTC inserted into docking gate; and
- Remove lid and inspect IFTC.

Transfer of Used Fuel and Placement of IFTC/M in Shipment Area

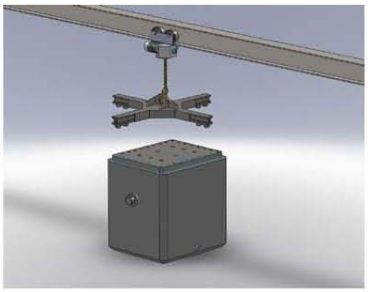
- Load modules into IFTC;
- Inspect IFTC/M and replace lid;
- Lower IFTC/M from Hot Cell and shuttle to loading pit;
- Attach lid bolts;
- Decontaminate outer shell of IFTC/M (if necessary) and perform contamination swipe;
- Transfer IFTC/M from Hot Cell pit and perform air pressure decay test;
- Transfer IFTC/M to shipping area; and
- Install impact limiter and security seals.

The total sequence duration to prepare the cask and load the used fuel into the IFTC is approximately 12 hours with a 20% allowance. This includes about 1.8 hours (1.5 hours with a 20% allowance) for a pre-loading inspection of the impact limiter, its placement on the filled cask and later transfer of the ready-to-transport IFTC/M to the transportation shipment area. All operations will require three personnel for the duration of the phased activities.

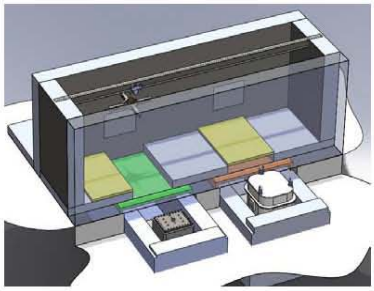
Hot Cell Transfer Sequencing of Operations
Preparation of IFTC Transport Cask



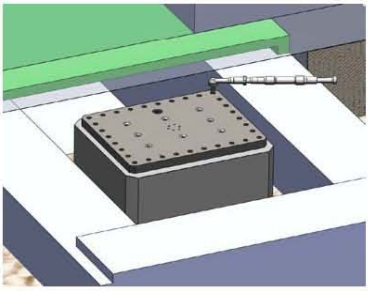
Phase I
IFTC Transport Cask in secure storage or Shipment Area



Phase II
Transfer IFTC from Storage



Phase III
IFTC transfer to Hot Cell Loading Pit



Phase IV
Remove IFTC Lid Lugs

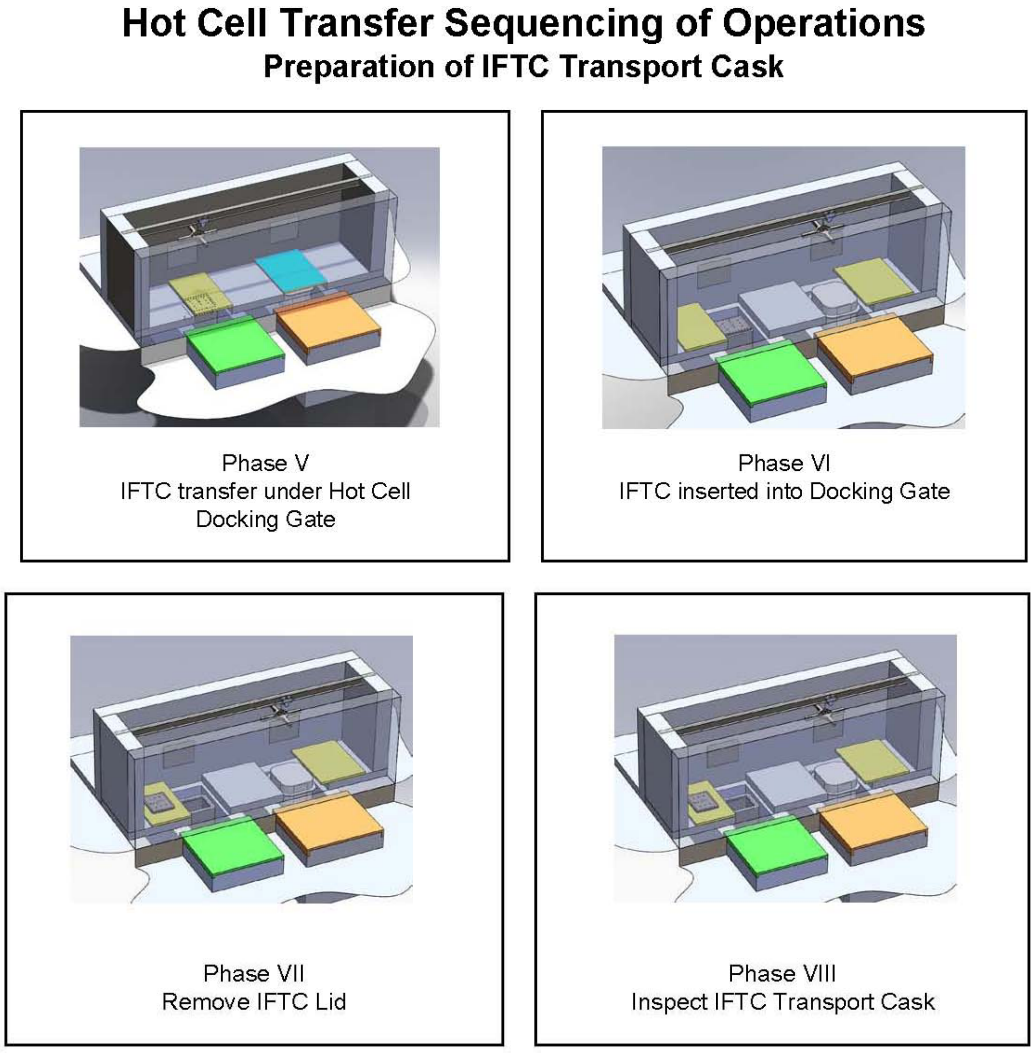
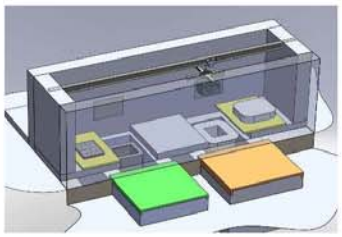


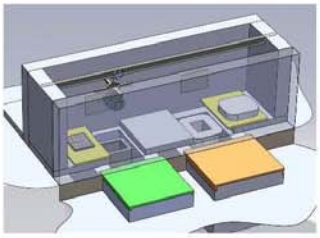
Figure 8: Preparation of IFTC

Hot Cell Transfer Sequencing of Operations

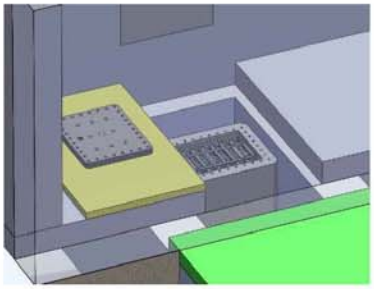
Transfer of Used Fuel and place IFTC/M Transport Cask into Shipment Area



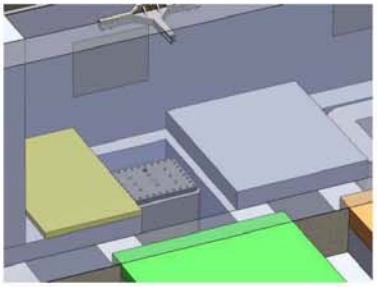
Phase I
Unloading Modules from
Owner's Cask



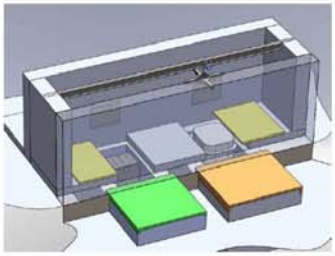
Phase II
Load Modules into IFTC
Transport Cask



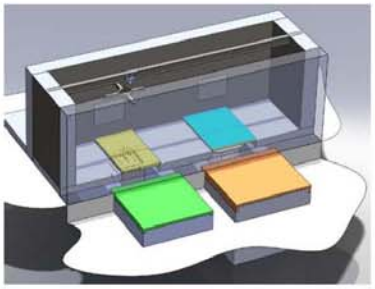
Phase III
Inspect IFTC Transport Cask



Phase IV
Place Lid on IFTC/M
Transport Cask



Phase V
Lower IFTC/M Transport Cask
from Hot Cell



Phase VI
Shuttle IFTC/M Transport
Cask to Loading Pit

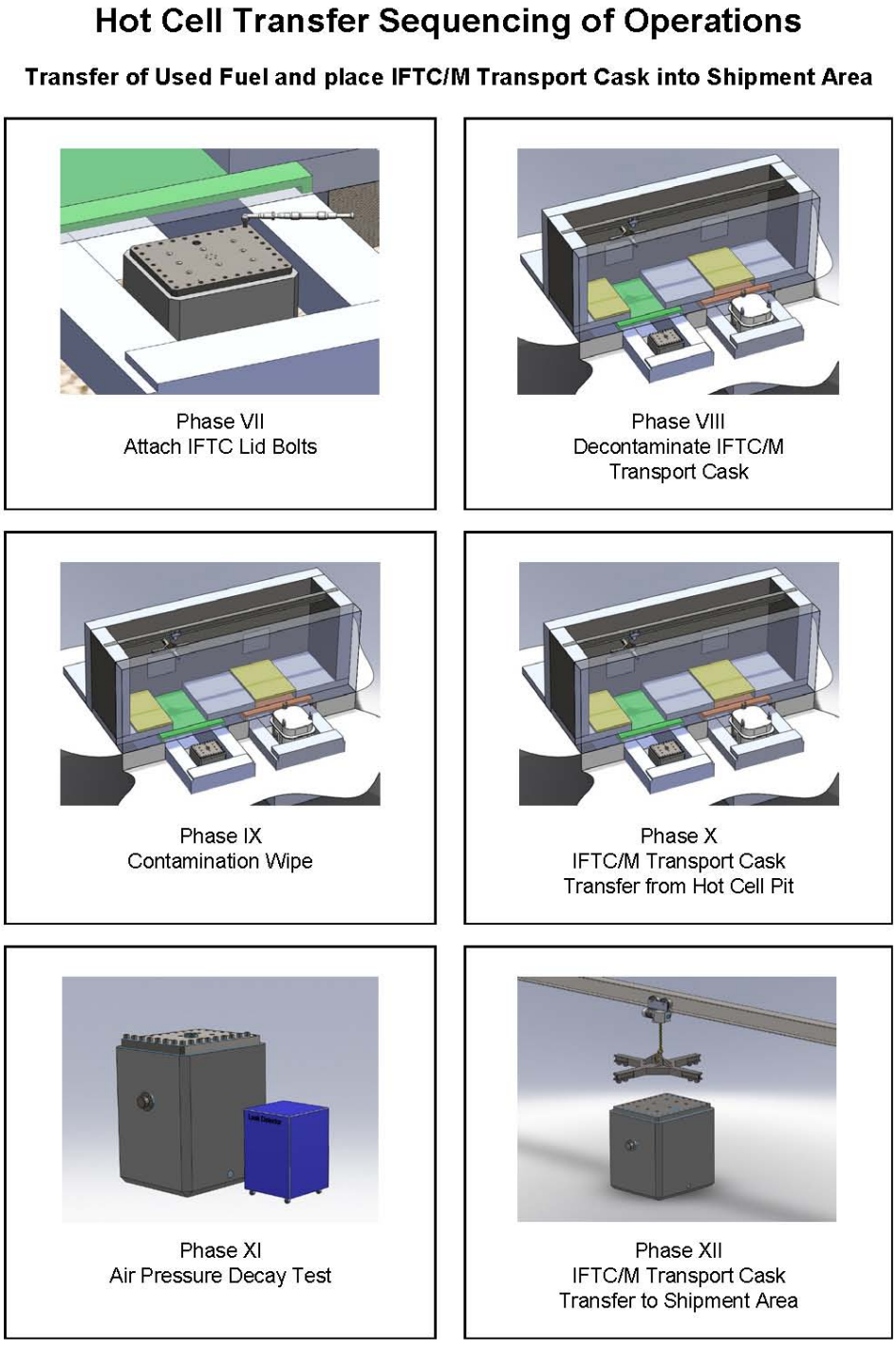


Figure 9: Transfer of Used Fuel and Placement of IFTC/M into Shipment Area

5.2 Labour and Infrastructure Requirements

Labour and equipment/building requirements required to support the used fuel transfer activities are described in this section.

5.2.1 Labour Needs

Anticipated time requirements to carry out the used fuel transfer process with the Hot Cell approach was previously presented in Sections 5.1.3. Considering the intended sites for the transfer approach (as noted on Table 6) the time durations needed to fill and prepare an IFTC in preparation for transport to the DGR are identified below on Table 8.

Table 8: Cask Loading Times by Reactor Storage Site

Owner	Sites	Total Loading Hours	Total Person-Hours
OPG	Pickering	13	39
	Darlington	13	39
	Bruce	13	39
AECL	Douglas Point		39
	Chalk River	14	42
	Whiteshell	14	42
	Gentilly 1	13	39
HQ	Gentilly 2		39
NBP	Point Lepreau	13	39

The total person hours per reactor storage facility were calculated by multiplying the total loading from the table above by three persons to account for the three personnel complement required for the duration of the component activities.

5.2.2 Cranes and Hoists

The lifting capacities of the gantry cranes and/or hoists required at the reactor storage site used fuel transfer areas are identified on Table 9. The identified capacities were derived taking into consideration the design specifications of the Owners' casks and cask lids, as well as those for the IFTC and any other equipment pertinent to the operation of the used fuel transfer process.

As noted on Table 9, the crane and hoist requirements depend on the used fuel transfer approach used. While crane and hoist capacities are identified for each transfer element, certain activities will actually share equipment of similar capacities.

Table 9: Crane/Hoist Requirements at Reactor Storage Sites

Equipment	Used Fuel Transfer Area		Transfer/Shipment Area		Crane/Hoist Capacity		
	Hot Cell (inside)	Shielded Transfer	Hot Cell (outside)	Shielded Transfer	55 t	30 t	10 t
Owner's Flask		✓		✓		✓	
Owner's Cask	✓		✓		✓		
Owner's Cask Lid	✓		✓				✓
IFTC	✓	✓	✓	✓	✓		
IFTC Lid	✓	✓		✓			✓
Impact Limiter			✓	✓			✓
UF Modules	✓	✓					✓

5.2.3 Transfer Facilities Buildings

As previously noted, the transfer approach to be used at Chalk River and Whiteshell requires further investigation to determine the location of the transfer activities. For the remaining storage sites, new transfer facilities will be established to house the new Hot Cells and related material handling equipment.

Although there is no hot cell at the used fuel dry storage facility at the Bruce reactor site, this facility can serve as a guiding model for a new hot cell facility. The Western Used Fuel Dry Storage Facility at Bruce is illustrated on Figure 10. Based on a simple area comparison using the approximate sizes of the Hot Cells and casks, it is estimated that the new site transfer facilities will be about 75% of the size of the Bruce operation.

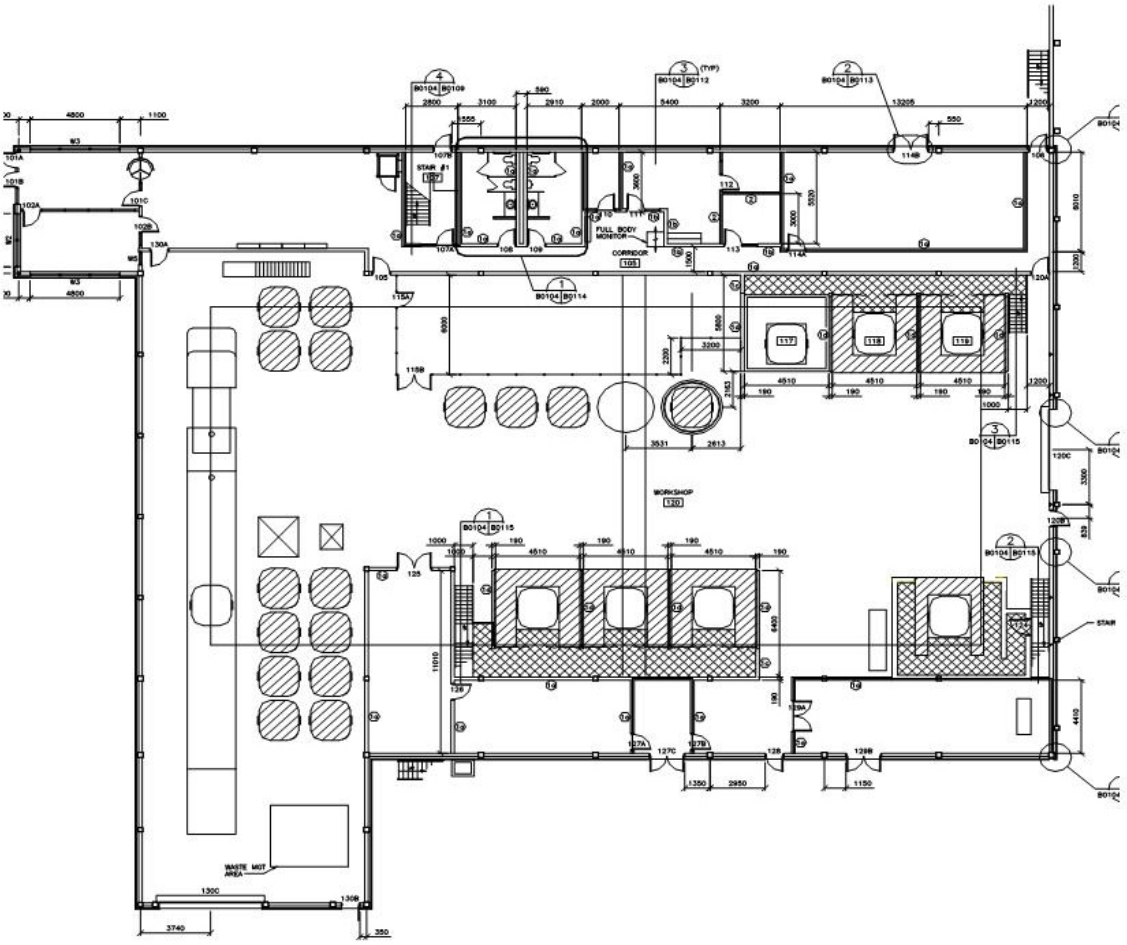


Figure 10: Bruce Used Fuel Dry Storage Facility

6. RATE OF USED FUEL SHIPMENTS

The total anticipated used fuel shipments (as bundles) for the Base Case and Alternate Case are illustrated below, based upon the data first presented in Section 4.4.

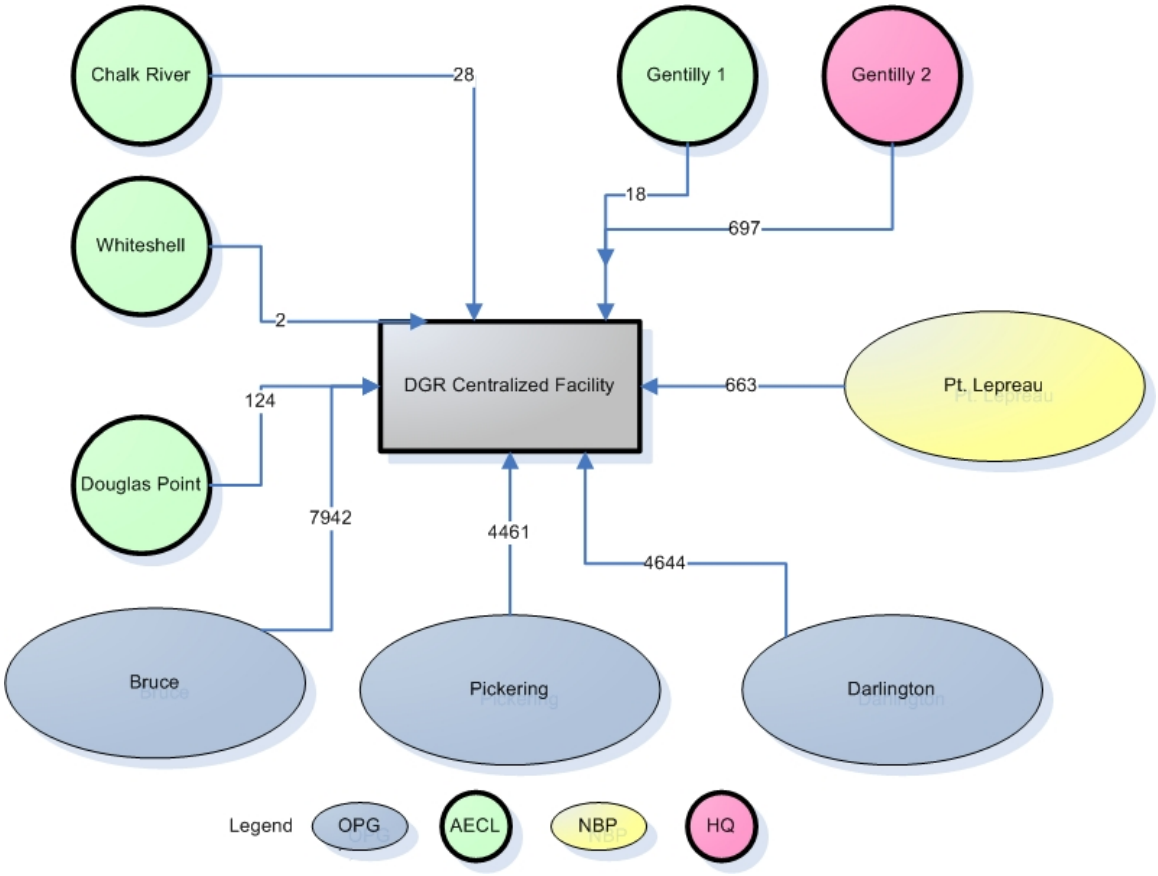


**Figure 11: Total Used Fuel Shipments by Facility:
Base Case (3.6 million bundles)**

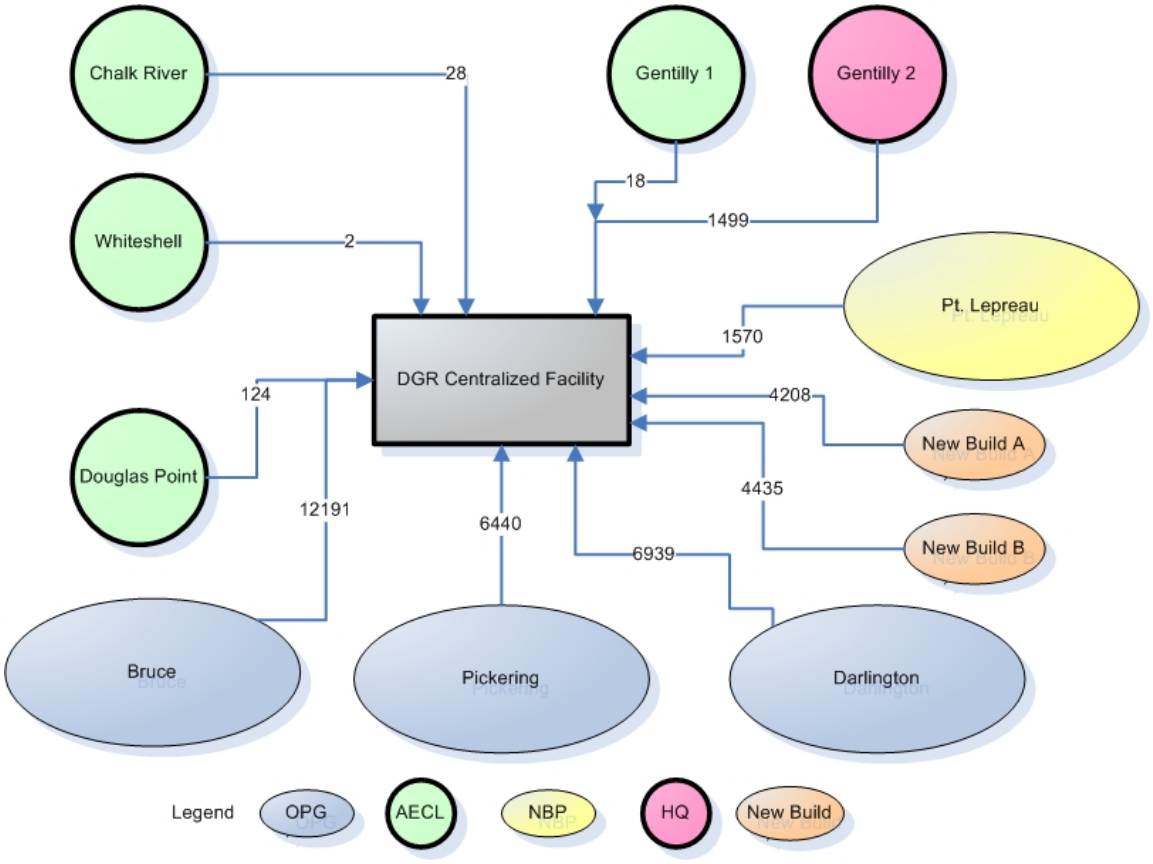


**Figure 12: Total Used Fuel Shipments by Facility:
Alternate Case (7.2 million bundles)**

The annual rate of used fuel shipments from the reactor storage facilities to the DGR is dictated by the rate of placement of used fuel at the DGR and the actual and projected used fuel inventories at the storage sites. With regard to the latter, delivery rates were partially determined by a desire to minimize fluctuations in the number of annual shipments per originating facility (i.e. to steady staffing levels).

With regard to the former influencing factor, the rate of used fuel processing at the DGR has been stipulated as 120,000 bundles per year for both the Base Case and Alternate Case fuel inventory scenarios. The target transport rate is to match this fuel placement rate as closely as possible minimizing the need to manage excessive contingency or buffer storage of used fuel at the DGR. In other words, the used fuel shipments are to be synchronized with the ability of the DGR to accept, repackage and place the used fuel at a rate of 120,000 bundles per year.

At an annual acceptance rate of 120,000 used fuel bundles, the average number of shipments per year will peak at approximately 630. This results in about 15 shipments per week arriving at the DGR, 42 weeks per year (the DGR is assumed to be unavailable for IFTC receipt 20% of

the year due to plant shutdown, inspection maintenance periods and downtime due to inclement weather).

Based on the forgoing, the projected annual number of used fuel shipments for the entire durations of the Base Case and Alternate Case were calculated. The estimated maximum values over the shipment periods are shown below on Table 10.

Table 10: Maximum Shipments per Year by Site

Sites	Base Case Shipments	Alternate Case Shipments
Pickering	166	160
Darlington	165	160
Bruce	295	305
Douglas Point	13	15
Chalk River	7	7
Whiteshell	2	2
Gentilly 1	5	5
Gentilly 2	52	47
Point Lepreau	47	46
New Build A		244
New Build B		384

The receiving and dispatch areas of the DGR's Used Fuel Packaging Plant (UFPP) will be designed to accommodate the projected weekly cask processing rates. In this respect, two hours have been allotted to unload an IFTC/M from an incoming transport trailer. An additional four hours is assumed to be consumed to inspect, test and load the empty IFTC back on the trailer for transport back to the reactor storage sites. Spare transportation vehicles will be in place at the DGR to allow these processing steps to occur off-line. Spare IFTCs will also be available to accommodate cask maintenance needs.

7. IFTC TRANSPORTATION EQUIPMENT

The IFTC transportation equipment consists of vehicles with the supporting auxiliary equipment to fasten the load and provide safety and security while in transit between the reactor storage facilities and the DGR. There are a number of constraints and requirements that must be satisfied when selecting the transportation system chiefly related to:

- Security related to the transport of Category II nuclear material; and
- Provincial vehicle size and weight limits for road transport.

In addition, there are generally accepted good practice principles to observe in selecting transportation equipment for use in long duration, long haul systems.

Provincial vehicle size and weight limits are discussed further in Section 7.2.1. With regards to meeting security requirements, the Category II specific measures from the CNSC Regulatory Guide G-208 on Transportation Security Plans stipulate that nuclear material in transport must be afforded a level of physical protection and security comparable to that provided for similar material during use or storage. Category II nuclear material packages (in this case the IFTC) should be shipped in closed, locked and sealed vehicles with the load itself secured to the vehicle.

Category II nuclear material shipments should also be accompanied by one or more escorts (e.g., nuclear security guards) providing constant surveillance of the shipment by travelling in the cargo vehicle or in an accompanying vehicle.

Based on the forgoing, and as illustrated on Figures 13 and 14, the transportation vehicle system may be comprised of:

- Transportation Vehicle (tractor and trailer); and
- IFTC (filled or empty) with impact limiter;

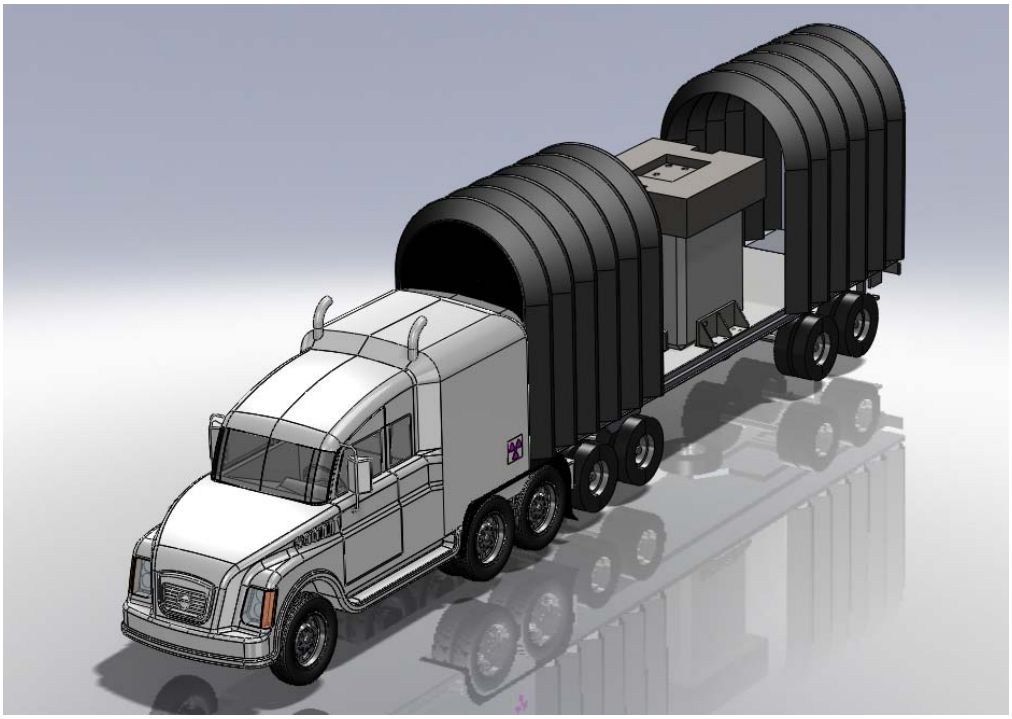


Figure 13: Transportation Vehicle System with IFTC - Weather Cover Open

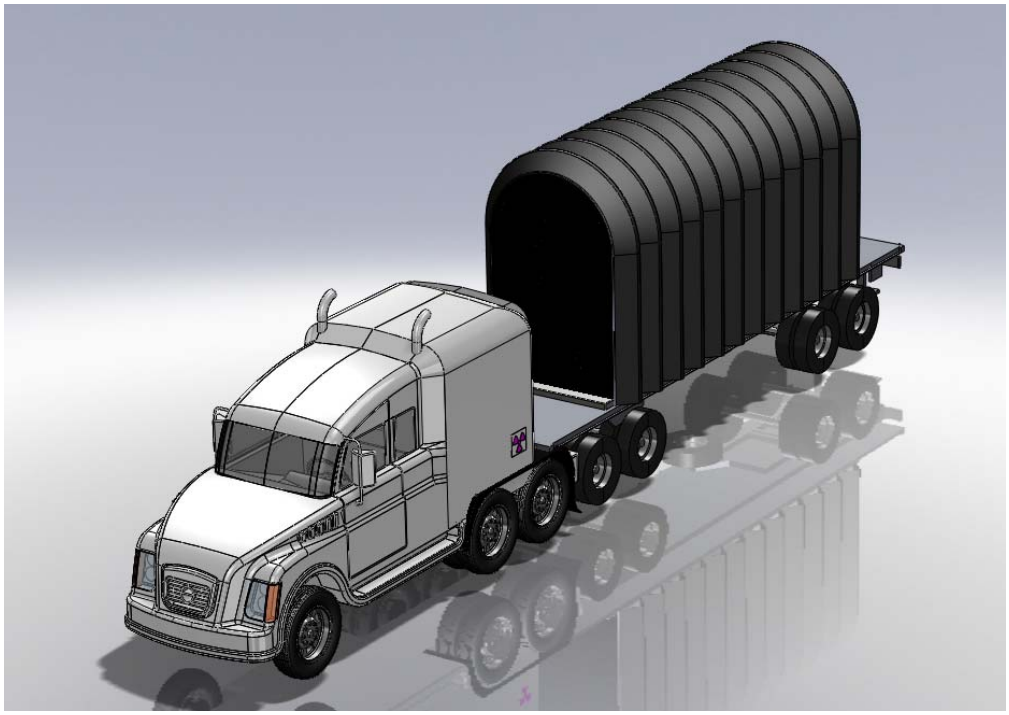


Figure 14: Transportation Vehicle System with IFTC - Weather Cover Closed

7.1 Transport Tractor

The transport tractor provides the motive power to haul the trailer. It must be capable of pulling a combined load of the trailer and a filled IFTC/M. Table 11 provides an estimate of the gross vehicle weight to be hauled by the tractor (including the tractor itself).

Table 11: Tractor/Trailer Gross Vehicle Weight Estimate

Load Description	Estimated Weight
Transport Tractor	9,000 kg
Transport Trailer (including weather cover)	7,000 kg
IFTC (empty) / IFTC/M (filled) – see Table 3	29,500 kg / 34,700 kg
Tie Downs	1,500 kg
IFTC Mounting Frame	1,000 kg
4 Occupants	360 kg
Total GVW Road Load (IFTC / IFTC/M)	**48,360 kg / 53,560 kg**

Vehicles are currently available in the commercial trucking industry to handle this magnitude of load. In addition to these power requirements, the transport tractors are assumed to have the following features:

- Extended cab with integrated sleeper berth for 2 persons;
- Speed limiters to meet provincial regulations;
- Radar based collision mitigation system to assist driver with avoiding collisions;
- Anti-theft electronic immobilizer system (e.g., biometric or handprint scanner);
- Passenger mounted LCD touch screen computer with GPS interface for communications with DGR central logistics;
- 2 GPS units (one as back-up) for remote real-time tracking of tractor location;
- Load protection barrier behind cab to help protect occupants in a sudden stop;
- Heavy duty alternator to accommodate the tractor's enhanced DC electrical peripherals;
- Tool box with relevant tools and spare parts; and
- Fire extinguishing equipment to meet the national fire code.

7.2 Transport Trailer

The following first describes the impact of provincial road regulations on the selection of the transport equipment. Features to be accommodated for in the trailer design are then listed.

7.2.1 Provincial Road Regulations

Truck transport in Canada is governed by provincial regulatory requirements that specify limitations on shipment size, weight and relative placement on a trailer. For the used fuel transportation system, given the location of the reactor storage sites and the assumed location of the DGR, the provinces of concern in this regard are Ontario, Quebec, New Brunswick and Manitoba.

Weight Based Criteria

A strict interpretation of the weight-based regulations requires that details are known about the proposed vehicle, number of axles, and the load. At this level of design, however, it is most important to be aware of the thresholds. In this respect the typical load limit for the noted provinces is 34,000 kg with a maximum allowable limit for the tractor, trailer and load of 55,500 kg. Based on the estimated gross vehicle weight for the tractor and trailer (see Table 11), it seems unlikely that overweight permits will be required for travel in all the provinces under normal weather conditions.

Load limits are also affected by weather conditions. For example, thaw conditions can reduce some road limits by up to 20% and, as a result, it is possible that overweight permits will be required in thaw conditions. At the present time the potential impact on the used fuel transportation system has been accounted for by reducing the system's overall availability by 20% (i.e. to an 80% level of availability).

Vehicle loading characteristics can be improved by designing a custom mounting frame or a custom trailer with an integral mounting frame to better spread the weight of the IFTC over the trailer's axles.

Dimensional Criteria

Dimensional regulations that must be met by the IFTC transportation vehicles for travel in the four subject provinces include a maximum width, length and height (vehicle and load) of 2.6 m, 23 m and 4.15 m, respectively. Given the approximate width, length and height of the concept IFTC transportation vehicles (again, vehicle and load) of 2.2 m, 19-21 m and 3 m, respectively, the envisaged transportation system will stay within the dimensional requirements.

Other Considerations

Other considerations will also come into play in the final selection of the transportation equipment. For example, based on recent regulatory changes, new semi-trailers must have a self-steering axle which enables the wheels to automatically take on the trajectory of the vehicle. The trailer axles must allow for equalization, without possible adjustment, of the mass under the wheels of each axle.

7.2.2 Transport Trailer Features

Trailers are currently available in the commercial trucking industry to handle loads similar to a filled IFTC/M. In addition to meeting the provincial requirements, the transport trailers are assumed to have the following features:

- Modified double-drop 14.6 m, 4 axle flatbed to minimize load height and center of gravity;
- Air ride suspension;
- Custom mounting frame to spread the load of the IFTC evenly across the axles;
- Custom integrated IFTC tie-down system;
- Custom weather cover for the IFTC;

- Marking and labelling, including hazardous material placards;
- 2 GPS units for the trailer (one as back-up) to facilitate remote real-time tracking of the trailer location. Independent power supplies will be required to run these units when the trailer is detached from the tractor;
- 2 GPS units for the IFTC (one as back-up) to facilitate remote real-time tracking of the cask location. An independent power supply will be required to run this unit to provide for the possibility of it being removed from the trailer;
- Space for auxiliary equipment such as a tool box, leak testing devices and spare parts; and
- Fire extinguishing equipment to meet the national fire code.

7.3 Security Escort Vehicle

A security escort vehicle may accompany the used fuel shipments. If required, this vehicle is assumed to have the following features:

- Radar based collision mitigation system to assist driver with avoiding collisions;
- Anti-theft electronic immobilizer system (e.g., biometric or handprint scanner);
- Passenger mounted LCD touch screen computer with GPS interface for communications with DGR central logistics;
- 2 GPS units (one as back-up) for remote real-time tracking of the vehicle location;
- Security and vehicle handling customization as typically performed on RCMP and provincial police vehicles; and
- Fire extinguishing equipment.

8. TRANSPORT TRAILER IFTC LOADING AND UNLOADING

This section deals with the operational sequencing and specific elements associated with the loading of an IFTC onto the transport trailer and its preparation for shipment. The unloading of the casks is also discussed.

The IFTC transportation vehicle loading system will combine elements of both push and pull inventory systems. With regards to the former, the return of empty IFTCs to the reactor storage sites to enter the buffer of unfilled casks is a form of push style inventory control. Pull inventory control is demonstrated when outgoing IFTC/Ms are taken from the reactor storage sites' buffer of filled casks.

8.1 Sequencing of Operations

The operational sequence covering vehicle preparation and cask loading/unloading is expected to be common amongst the various reactor storage sites. The specific steps for the preparation and loading of the IFTC/M transport vehicle are presented below along with estimated cycle times. Unloading operations at the reactor sites for the returned (and empty) IFTCs are then addressed.

The sequencing of operations at the DGR's Used Fuel Packaging Plant are expected to be similar but reversed to that described below.

Preparation of Transport Vehicle

- Arrival of incoming empty transport vehicle;
- Pre-loading inspection of transport vehicle; and
- Position transport trailer for loading of IFTC/M.

Transfer of IFTC/M onto Transport Vehicle

- Load IFTC/M with impact limiter onto transport trailer;
- Attach tie-downs to IFTC/M assembly (see Section 8.3);
- Post-loading inspection;
- Perform contamination swipe including radiological survey;
- Close weather cover on transport trailer;
- Final inspection of transport vehicle; and
- Deployment of loaded IFTC/M transport vehicle.

Removal of IFTC from Transport Vehicle

- Arrival of incoming transport vehicle with empty IFTC;
- Open weather cover on transport trailer;
- Inspect transport vehicle with empty IFTC (and impact limiter);
- Perform contamination swipe including radiological survey;
- Remove tie-downs on IFTC assembly; and
- Unload IFTC with impact limiter from transport vehicle.

The total sequence duration to prepare an empty transport vehicle and load an IFTC/M is approximately 4 hours with a 20% allowance. The total duration to unload a returned and empty IFTC is approximately 2 hours with a 20% allowance. Both operations will require three personnel for the duration of the phased activities.

8.2 Parallel Processing Requirements

Using the identified durations for the described sequences, a time comparison was conducted to determine if parallel operations were required at any of the reactor storage sites. This comparison was based on the available time for a single lane process conducted over 365 days per year, 24 hours a day and with an 80% availability being equivalent to 7008 hours. This assumes a total transport vehicle loading and unloading process time of 7 hours (including an additional 1 hour allowance).

Table 12 identifies the peak number of annual shipments from the various reactor storage sites under either the Base Case or Alternate Case used fuel scenario. Upon examination of the corresponding yearly material handling times it is apparent that there is no need for parallel loading processes at any of the reactor sites (or at the DGR itself). That is, all of the identified annual material handling times are well below that available from a single line process.

Table 12: Transport Vehicle Loading/Unloading Requirements

Reactor Storage Site	Peak Annual Shipments	Yearly Material Handling Time
Pickering	166	1162 hours
Darlington	165	1155 hours
Bruce	305	2135 hours
Douglas Point	15	105 hours
Chalk River	7	49 hours
Whiteshell	2	14 hours
Gentilly 1	5	35 hours
Gentilly 2	42	294 hours
Pt. Lepreau	50	350 hours
New Build A	244	1708 hours
New Build B	385	2695 hours
DGR	630	4410 hours

8.3 IFTC Tie-Down System

The currently certified IFTC design incorporates a tie-down system that utilizes side mounted trunnions and guide blocks. This system will provide adequate securing of the IFTC or IFTC/M onto the transport trailer.

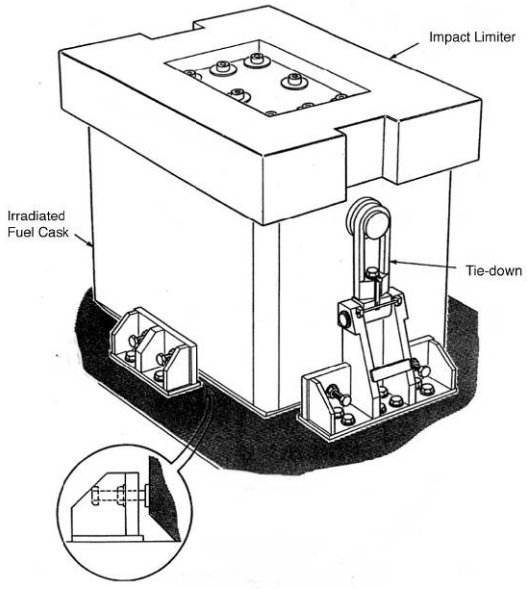


Figure 15: IFTC Tie Down System

9. TRANSPORTATION LOGISTICS

Transportation logistics comprises two basic elements that should be performed with speed and reliability: routing and scheduling. The following discussion introduces key parameters that will guide the eventual detailed design of these elements. The discussion will apply to the Base Case and the Alternate Case as they are anticipated to be very similar except for the duration of shipments. Some of the effects of a longer shipping duration in the Alternate Case are:

- Increased number of equipment replacements;
- Opportunity to incorporate new technologies as they become available; and
- Personnel change-over considering the extended duration of transportation operations.

While the following discussion does not address the entity undertaking the transportation functions, it is anticipated that some transportation work areas such as dispatching, in-transit tracking, receiving and emergency response could be outsourced.

9.1 Route Management and Selection

Route management consists of the balancing of shipment rates with the available transport team, vehicles, loading and unloading times. There are also the issues of balancing driving time regulations, worker morale and union regulations to accommodate the non-stop nature of the used fuel transportation operations. Route management is constrained by consideration of the following:

- Regulatory requirements associated with the transport of Category II nuclear material as well as Canadian truck driving regulations;
- Efficient dispatching and receiving of transport teams; and
- Highway classifications.

Regulatory requirements that must be followed for the transport of Category II nuclear material are shown below in Table 13.

Table 13: Regulatory Requirements for Category II Nuclear Material Shipments

Route Management Requirements for Category II Nuclear Material Shipments
When choosing routes for the transport of nuclear material, the applicant should take into account any obvious hazards, such as rockslides, floods or forest fires, that could adversely affect the transport at certain times.
The total time that the nuclear material remains in transport should be minimized.
The number and duration of any transfers of the nuclear material from one conveyance vehicle to another, or to and from temporary or longer-term storage, should be minimized.
Fixed transport schedules for the movement of the nuclear material should be avoided.
The routes used to transport the nuclear material should be varied, taking into account applicable regulations and ordinances regarding transport routes for radioactive and hazardous materials.

Source: Ref [2] - CNSC's Regulatory Guide G-208 Transportation Security Plans for Category I, II or III Nuclear Material, March 2003;

Trucking regulations and transport team management are dealt with in subsequent sections. With respect to highway classifications, it is currently assumed that all used fuel transportation will be conducted over roadways and highways of a Class B minimum. Significant road upgrades are currently not assumed to support the transportation system.

In terms of route selection, the actual travel routes to be used from the used fuel storage facilities to the final DGR location will be determined in consultation with potentially affected communities. However, the relevant variables that will ultimately guide the route selection can be introduced. The most important variables are:

- Seasonal load capacity restrictions on travelled roadways;
- Load height and weight restrictions along routes;
- Past and projected frequency of road maintenance for the road corridors;
- Potential emergency response times; and
- Available road assistance infrastructure (e.g., garages) along routes.

9.2 Canadian Truck Driving Regulations

Truck driving rules throughout Canada are established in the Commercial Vehicle Drivers Hours of Service Regulations (SOR/2005-313). These regulations dictate the rules for hours of service in a driver's day-to-day activity that must be followed.

A person is considered 'on duty' when performing work related activities (other than driving) such as pre-trip inspections, loading, unloading or waiting for a load. They are considered 'off duty' for any time spent on activities not directly related to the work such as break times and shower times. The critical rules that affect the hours of service for driving are:

- No operator shall drive after they have accumulated 13 hours of driving time or 14 hours of on-duty time in a day unless they take at least 8 consecutive hours of off-duty time before driving again;
- No operator shall drive after 16 hours of time have elapsed between the conclusion of the most recent period of 8 or more consecutive hours of off-duty time and the beginning of the next period of 8 or more consecutive hours of off-duty time;
- A driver must take at least 10 hours of off-duty time in a day;
- Off-duty time other than the mandatory 8 consecutive hours may be distributed throughout the day in blocks of no less than 30 minutes each;
- The off-duty time shall be at least two hours and may be added to the mandatory eight consecutive hours of off-duty time but cannot form part of it;
- Each driver must follow either a 7-day or a 14-day cycle; and
- A driver under a 7-day cycle cannot drive again in that cycle after accumulating 70 hours of on-duty time during any period of seven days or during the period beginning on the day on which the cycle was reset.

9.3 Transport Team Management

Considering the impact of the preceding regulations, driving cycle times were calculated for each of the reactor storage sites. For all facilities except those at Gentilly 1&2 as well as Point Lepreau, a 38 hour return trip cycle time is anticipated based on the distance travelled. For Gentilly 1&2 and Point Lepreau, the return trip driving times are assumed to be 54 and 80 hours, respectively. These figures include a one hour allowance for dispatching and receiving at both the origin and destination points. Other additional assumptions considered in this analysis include:

- All driving cycles are planned to start and end at the DGR;
- Cycles are based on a 7 day - 70 hour cycle as per Provincial regulations;
- Rapid dispatch and receiving will be practised at the DGR and the reactor storage sites. As discussed below, this is accomplished in part by using spare vehicles pre-loaded with IFTC/Ms at the reactor storage sites;
- Average vehicle speeds of 60 km/hr are achievable for Ontario and Manitoba; and
- Average vehicle speeds of 80 km/hr will be possible for areas east of Ontario for routes to and from the Gentilly and Pt. Lepreau storage sites (travel will primarily be on major highways).

For each of the driving cycles a team of 4 individuals will be required. At any given time there will be two people on-duty and two off-duty.

For the efficient and regulatory compliant operation of the used fuel transportation system the alternate team members must be off-duty when the primary team is on-duty. The alternate team members will be immediately available at switching times as they will be accommodated in the sleeper berth. There is expected to be minimal shared on-duty time at switchover points.

Rapid Dispatching and Receiving

In order to facilitate the efficient operation of the transportation system the concept of rapid dispatching and receiving of shipments will be introduced. This involves placing additional IFTC transportation vehicles at strategic sites to allow the cask handling processes to occur in parallel with the actual driving. The advantages of such a system include:

- Parallel tasks can take place independently of one another. Some vehicles can be on-route while others are being loaded or unloaded;
- Shipments are pre-loaded, inspected and placed in a secure area ready for pickup;
- Driving teams are able to perform a round-trip in the minimum time possible;
- The in-transit times for the Category II nuclear material shipments are minimized;
- Rush scenarios where a transport team arrives and the outgoing shipment is not ready are eliminated; and
- Alternate vehicles are available in an emergency scenario.

9.4 Transportation Equipment Quantities

Based on the above considerations, the required transportation vehicle fleet sizes were determined. The main factors driving the fleet sizes were:

- Driving cycle times by reactor storage site;
- Site-specific peak yearly shipments to the DGR;
- Expected annual transportation system 'on time' equivalent to 80% of 24 hours X 365 days = 7008 hours (that is, the time the transport system is in operation); and
- Availability of alternate vehicles and casks at the reactor storage sites and DGR (to allow for parallel tasking and to cover for maintenance downtime).

The assumption of an 80% availability for the used fuel transportation system is meant to reflect the potential impacts of external factors to the continual functioning of the transport fleet. Such factors will include weather and traffic related delays, maintenance downtime as well as travel time differences for the Category II nuclear material alternate haulage routes.

A summary of the calculated transportation equipment quantities for the Base Case and Alternate Case is provided on the following Table 14.

Table 14: Transportation Equipment Quantities

IFTC Transportation Vehicle	Minimum Quantity to operate UFTS		Alternates for Rapid Dispatch and Receiving		Spares for Maintenance		Totals	
	Base Case	Alternate Case	Base Case	Alternate Case	Base Case	Alternate Case	Base Case	Alternate Case
Tractor	6	7	5	5	2	2	**13**	**14**
Trailer	6	7	12	14	0	0	**18**	**21**

The equipment numbers presented on Table 14 assume that transport trucks and/or trailers are not shared between the Owners' sites. The identified equipment numbers may be optimized

(i.e. reduced) by incorporating such sharing between the reactor storage sites as might be allowed by the associated different peak yearly shipment schedules.

10. MAINTENANCE AND INSPECTION OF TRANSPORT SYSTEM

10.1 Equipment Maintenance and Replacement

Vehicle maintenance and replacement requirements for the used fuel transportation system are expected to be substantially similar to those associated with commercially available equipment currently in use in the trucking industry. As the tractors and trailers are not expected to experience any direct radiological contamination, third party trucking industry maintenance providers can be contracted to manage their maintenance and care. The assumed level of such care (the maintenance standards) will, considering the duty imposed, be set to a significantly more stringent standard than that for similar commercial transport equipment. As a result, the downtime due to failure or equipment malfunction will be minimal.

The location of the vehicle maintenance shops could either be near the DGR or a major metropolitan centre where existing third party facilities are located. As previously noted, an allowance of 80% availability has been assumed for the transportation system to account for, among other things, maintenance downtime (including tire replacement). Vehicle replacement intervals will be set based on a conservative approach to current trucking industry practices.

Maintenance for the IFTC transport trailer loading system will also be typical of material handling equipment in the nuclear industry. It is anticipated that reactor storage facilities will have previous experience and established practices in the care of this type of equipment.

With respect to the transportation system logistics equipment (electronics and computer based systems – see Section 11), this is further expected to be typical of that in routine use in the trucking sector. Maintenance practices will, therefore, be well understood although the externally mounted GPS units can be expected to need additional attention as they will be periodically exposed to harsh environments. Spare GPS units will be available at both the DGR and the reactor storage sites for easy replacement.

Taking into account the rapid pace of change for this technology and the opportunity for incorporating new advances in the field, logistics equipment should be expected to be replaced on intervals of no greater than every 10 years.

10.2 Equipment Inspection

Equipment inspection requirements for the transportation vehicles (tractor and trailer) are well understood and typical of those in place in the trucking industry.

Inspection requirements for the IFTC transport trailer loading system will be based on those mandated for Category II nuclear material shipments. They include checking the integrity of package locks and seals before departure, during the journey and on arrival at the final destination, in order to detect any tampering. Before a vehicle is loaded with a shipment of used fuel, qualified personnel are also to conduct a rigorous search of the vehicle to ensure that there has been no attempt to sabotage it.

As with the maintenance practices, it is anticipated that the reactor storage facilities will have experience with the level of inspections required for the transport of nuclear material.

11. SAFETY AND SECURITY OF TRANSPORT SYSTEM

Measures intended to be implemented to ensure safety and security across the used fuel transportation system are discussed in this section.

11.1 System Safety

Safety protocols for the used fuel transportation system will commence with that established for the loading of the IFTC transport trailers. Expected to be typical of those for material handling in other industries, such measures will include visual and audible beeper devices to warn workers of equipment operations. Mechanical and electrical lockouts will also be in place as well as labelling to clearly communicate load capacities and equipment travel limits. Fire extinguishing systems will further be available.

Considering the characteristics of the handled nuclear material, permanent radiation detection equipment to continually monitor work areas will be established. Portable radiation detection equipment to pinpoint specific problem areas will also be procured.

While in transit, two-way text and data communications will be maintained with the Communications Centre and local authorities (among others). Panic buttons will additionally be installed in the transport tractors to allow drivers or escort personnel to send out urgent calls for help during an emergency.

Placarding and labelling as dictated by the package type and contents (used nuclear fuel) will be displayed on the vehicles. In addition, fire extinguishing equipment will be available on the transport tractor and trailer.

As an additional measure of safety, speed limiting will also be in place. Currently required on trucks in Ontario, a built-in electronic control module (ECM) allows one to install equipment to track fuel, engine efficiency and govern the speed of the truck. Monitoring of vehicle speed for unsafe driving practices is an on-board function.

11.2 System Security

The CNSC's Regulatory Guide G-208 Transportation Security Plans for Category I, II or III Nuclear Material (March 2003) provides guidance for nuclear material shipments. With respect to Category II material and in addition to obtaining the necessary licences, this includes:

- Shipments should be accompanied by one or more escorts, such as nuclear security guards;
- Before loading, qualified personnel should conduct a rigorous search of the vehicle to ensure that there has been no attempt to sabotage it. Immediately following this search, the vehicle should be locked and placed in a secure area pending it's loading for transport;
- Once loaded and in transit, the transport vehicle should be locked and sealed when not on the move, and should never be left unattended;

- The trustworthiness of everyone involved in the transport practices should be verified in advance of the shipment; and
- The length of time the shipment is in active transport should be minimized.

As previously described, the used fuel transportation system will rely on a convenient switchover of transport personnel at both the reactor storage sites and the DGR. This will be facilitated by the presence of pre-loaded and inspected vehicles ready to go when the transport team arrives. As a result of this, and consistent with the previously listed security requirements, secure areas will be provided at both the reactor storage sites and the DGR to hold the loaded transportation vehicles awaiting departure

Once in transit and in normal crew rotation, the security escorts will provide the necessary oversight while the vehicles are temporarily stopped. This will allow use of normal commercial truck locations and rest facilities located throughout the highway system. In the event that a longer duration unscheduled stopover becomes necessary, the escort will again provide the necessary security to permit the use of commercial truck stop locations (in fact, a stop-over could essentially be made at any point on-route as long as local authorities are notified).

As a further security measure, remote vehicle immobilization will be installed for the transport tractor. Such technology will be a useful feature in the event of unauthorized use of the vehicles.

Additional aspects of security as related to communications and real time tracking and monitoring are dealt with in the following sections.

11.2.1 Communications Requirements

Noted items from the CNSC's Regulatory Guide G-208 as related to communications during a Category II nuclear material shipment include:

- Communications shall be by encrypted messages only (the use of cell phones to send unencrypted messages regarding shipments is not recommended);
- The escort should remain in frequent contact with the shipper/receiver, as well as with local authorities and response forces along the transport route;
- A back-up plan of action should be in place in the event that communications are lost during shipment; and
- The establishment of a transport security control centre should be considered to coordinate the material transport and to make sure that secure and reliable communications are in place at all times.

These requirements will be met in the implementation of the used fuel transportation system. Encrypted satellite phone technology or other similar technology will be established, for example, and a centrally located Communications Centre (tracking centre) will be set up. The Centre will incorporate communication links with the reactor storage sites as well as the local authorities and emergency response forces along the transport route.

11.2.2 Real Time Tracking and Monitoring

Real-time tracking and monitoring of the vehicle fleet will be undertaken for the used fuel transportation system. The advantages of real-time tracking and monitoring are:

- The provision of accurate up-to-date information on the location of all tracked equipment, 24 hours a day;
- Integration with vehicle dispatching to achieve smooth transportation system operation;
- Immediate identification of problem areas in the transport system;
- Continuous on-board monitoring of vehicle speeds or un-safe driving practices;
- Emergency scenario tracking and response; and
- Transportation system record archiving and data analysis.

While there are a number of available technologies that can currently provide these abilities, the dominant method utilizes satellite technology, commonly referred to as a Global Positioning System (or GPS). Such tracking systems are currently in widespread use for commercial and government trucking fleets throughout North America and there are a variety of systems catering to different levels of security, performance reliability and cost. In view of the shipment characteristics for this application (Category II nuclear material) it was decided that security and performance features would take priority. As a result, the main features recommended for the used fuel tracking system will include that listed in Table 15.

Table 15: Real-Time Tracking System Features

Real-Time Tracking System Features
Real-time GPS tracking based on secure satellite communications and featuring: • Encrypted communications; • System redundancy (e.g., if main office goes offline, provision is made for fleet tracking to be shifted immediately to an alternate location); • Polling frequency for vehicle or cask location every 15 minutes. Polling refers to the transmission of location coordinates to the Command Centre; and • Integration of vehicle dispatch system with software APIs.
Rugged, tamper-proof GPS tracking devices intended for harsh environments located in each of the following locations: • Transport tractor (2 units,1 for back-up); • Transport trailer (2 units, 1 for back-up with an additional battery power source in the event that the trailer is separated from the tractor); and • IFTC or IFTC/M (2 units, 1 for back-up with an additional battery power source in the event that the cask is separated from the tractor and trailer).

Real-Time Tracking System Features
GPS console for in-vehicle use (tractor) that feature: • Customizable user interfaces and software; • Keypad controls usable by an individual with heavy gloves; and • Driver authentication to prevent unauthorized use.
Centrally located tracking centre / Communications Centre featuring: • Redundant computer systems to track all active GPS units; • Interfaces with the transport vehicle dispatch system; • Real-time tracking displays; • Surge protection and UPS emergency power backup; and • Communication links with reactor storage sites as well as local authorities and emergency response forces along the transport route.

Tracking of the GPS units will also occur inside covered environments (e.g., reactor storage site warehouses) to allow continuous monitoring of the used fuel casks while they are in storage and provide a clear high level view of work in process and prepared inventory. This will assist in predicting potential transportation system bottlenecks. Site-specific methods of boosting the GPS signals while indoors will need to be addressed.

It should be noted that real-time vehicle tracking is a rapidly changing field due to its reliance on electronics and satellite technology. Efforts will be made to stay abreast of new advances in the field.

12. EMERGENCY RESPONSE

Emergency response will be an important component of the used fuel transportation system's logistics not only from the perspective of ensuring best practice standards but also to support a public perception of competence. Provision must be made for all possible emergency scenarios that can be anticipated, documentation of which will be contained in an approved emergency response assistance plan (ERAP) as required under the guidelines of the Canadian Transport Emergency Center.

Additionally, the requirements for emergency response associated with Category II nuclear material shipments are to include that listed in Table 16.

Table 16: Emergency Response Requirements

Response Requirements for Category II Nuclear Material Shipments
Provisions for the support of response forces along the transport route.
Procedures for establishing effective communication, during transportation, with the response force from any involved jurisdiction or agency.
Contingency arrangements to address such events as a mechanical breakdown of a transport vehicle, or a failure of the shipment to arrive at its destination at the expected time.
Procedures to be followed during any scheduled stop, or unscheduled delay, during transport.
Provisions for notifying any response force along the transport route in advance of the actual shipment.

12.1 Emergency Response Teams

For the used fuel transportation system the emergency response resources will consist of teams organized as follows:

- **Command and Decision Team**. Duties will include:
  - Logistical and technical assistance to authorities;
  - Decisions on proper technical means to be implemented; and
  - Management of other teams.

- **Technical Analysis Team**. Duties will include:
  - Estimation of the technical state of the packaging and associated impacts; and
  - Proposition of technical emergency and assistance solutions.

- **Mobile Command Team**. Duties will include:
  - Implementation of command, information and expertise near an incident;
  - Provision of first intervention equipment (satellite communication system, radiological or chemical protection and other equipment as necessary); and
  - Implementation of processes to minimize consequences or to bring solutions to a situation.

- **Communications Team**. Duties will include:
  - Preparation and development of crisis communications;
  - Provision of a specific communications plan;
  - Provision of incident information to regulator;
  - Provision of information to press/media and other communication entities; and
  - Acceptance of information from the press.

12.2 Emergency Response Equipment

The first response to any emergency is expected to initially rely on equipment from local responders and authorities (police, RCMP, local fire departments). Consistent with the stipulated requirements for Category II nuclear material transport, these agencies will already have been made aware of any shipments through their territory.

To deal with more extreme emergency scenarios (including the recovery of an IFTC or IFTC/M), an all-terrain portable emergency crane would be available for dispatch to any required location within 48 hours. The crane will have a 90 tonne capacity to allow pickup of a 45 tonne load at extended reach. It will further be capable of travelling at 85 km/hr to minimize arrival times to the emergency site after dispatch.

A representative picture of a portable emergency crane is shown in Figure 16.



Figure 16: Portable Emergency Crane

In addition, a spare tractor and trailer vehicle will be available at the DGR to transport any retrieved IFTCs. Ready-to-employ lifting beams for the IFTC and impact limiters will also be located at the DGR and at the Bruce, Darlington and Gentilly reactor storage sites. Other assist equipment and supportive manuals and procedures will further be in place.

To maintain a high level of competence in procedures, annual emergency response exercises will be performed with this equipment.

TECHNICAL REFERENCES

Canadian federal acts, regulations and codes apply to all aspects of the used fuel transportation system. A full list of the applicable codes, standards and regulations are listed in Used Fuel Geologic Repository and Transportation System - System Requirements for the APM Update, APM-PR-01110-0001-R01, July 29, 2009.

List of Specific References

1. Used Fuel Geologic Repository and Transportation System - System Requirements for the APM Update, APM-PR-01110-0001-R01, July 29, 2009;

2. CNSC's Regulatory Guide G-208 Transportation Security Plans for Category I, II or III Nuclear Material, March 2003;

3. Stahmer, U. 2009. Used Nuclear Fuel Inventory and Transportation Estimates. Nuclear Waste Management Organization Report NWMO TR-2009-21;

4. Transportation of Dangerous Goods Regulations, including Amendment 6, SOR/2008-34, February 20, 2008;

5. NWMO background papers, 6. Technical Methods, 6-7 Status of Storage, Disposal and Transportation Containers for the Management of Used Nuclear Fuel, August 2003;

6. Packaging and Transport of Nuclear Substances Regulations, SOR/2000-208 31 May 2000, plus amendments SOR/2003-405;

7. IAEA Safety Standards Series, Regulations for the Safe Transport of Radioactive Material, 2009 Edition, No. TS-R-1 (ST-1, Revised);

8. Transport Logistics for Used Fuel Shipping to a Centralized Facility, Gaensbauer, A. 2010 approved by NWMO email 2010-02-02; and

9. Commercial Vehicle Drivers Hours of Service Regulations, SOR/2005-313.

DOCUMENT END

APPENDIX A

REACTOR USED FUEL STORAGE FACILITIES

As previously discussed in Section 3, used fuel managed at the Deep Geological Repository will originate from 22 CANDU commercial power reactors in Canada, 20 of which are situated in Ontario with additional locations in Québec and in New Brunswick. The main reactors in Ontario, owned by Ontario Power Generation (OPG), are located on the Pickering, Bruce and Darlington sites. The reactor near Bécancour, Québec (Gentilly 2), is owned by Hydro-Québec and the Point Lepreau reactor in New Brunswick is owned by New Brunswick Power.

In addition to these commercial power reactors, there are also four partially decommissioned demonstration reactors identified as Chalk River, Douglas Point, Gentilly 1 and Whiteshell, all under the jurisdiction of AECL.

All of used nuclear fuel material from these locations will be received at the DGR. In addition, under the Alternate Case, two new reactors are also assumed to have been established. The New Build A and New Build B power plants are assumed to be located somewhere in Ontario.

The basic parameters affecting the UFTS design are presented for each of the reactor storage sites. In the following tables year 1 (Y1) is assumed to be 2010.

A.1 OPG's Pickering Site

The Pickering reactor site is located on the north shore of Lake Ontario, 32 km east of Toronto. It has two stations, Pickering A and Pickering B each with four reactors, and the entire 240 ha site is fenced with access restricted and controlled by OPG. All used fuel produced by the Pickering Nuclear Generating Station is stored in the station wet bays and at the Pickering Used Fuel Dry Storage Facility.



The following lists the important Pickering site parameters relevant to the UFTS.

Parameter	Base Case	Alternate Case
Assumed distance to the DGR by road	1,000 km	1,000 km
Total number of shipments over the project duration	4,461	6,440
Duration of shipments	Years 26-55	Years 26-66
Reactor site production to occur in parallel with shipments to the DGR?	No	Yes

In the Alternate Case, the continued use of the Pickering reactors in parallel with shipments to the DGR affects the presumed availability of the turbine hall for shipments. A new facility would be required to handle shipping for the Alternate Case.

A.2 OPG's Darlington Site

The Darlington site is located about 70 km east of Toronto on the north shore of Lake Ontario, in the Regional Municipality of Durham. The 485 ha site is fenced, and access is restricted and controlled by OPG. The Darlington Nuclear Generating Station with four reactor units is located on the site and all used fuel produced by the station is stored in the station wet bays and at the Darlington Used Fuel Dry Storage Facility.



The following table provides the important Darlington site parameters relevant to the UFTS.

Parameter	Base Case	Alternate Case
Assumed distance to the DGR by road	1,000 km	1,000 km
Total number of shipments over the project duration	4,644	6,939
Duration of shipments	Years 26-55	Years 26-69
Reactor site production to occur in parallel with shipments to the DGR?	No	Yes

A.3 OPG's Bruce Site

The Bruce Nuclear Power Development, hereafter referred to as the Bruce site, is located within the County of Bruce. The site has been leased to Bruce Power since May 2001 with parts of the property, including the Western Waste Management Facility, retained by OPG. The site covers 932 ha and it is fenced, with access restricted and controlled by Bruce Power. Bruce Nuclear Generating Stations A and B , each with four reactor units, are located on the site and all used fuel produced by the station is stored in its wet bays and at OPG's Western Used Fuel Dry Storage Facility.



The following table provides the important Bruce site parameters relevant to the UFTS.

Parameter	Base Case	Alternate Case
Assumed distance to the DGR by road	1,000 km	1,000 km
Total number of shipments over the project duration	7,942	12,191
Duration of shipments	Years 26-55	Years 26-77
Reactor site production to occur in parallel with shipments to the DGR?	No	Yes

A.4 AECL's Douglas Point Site

The Douglas Point Nuclear generating station, located on the Bruce site, was permanently shut down in 1984 after 17 years of operation. In late 1987 used fuel bundles were transferred into concrete silos located external to the station. This storage facility is located approximately 1.5 km west of OPG's Western Used Fuel Dry Storage Facility on the Bruce site.



The following table lists the important Douglas Point site parameters.

Parameter	Base Case	Alternate Case
Assumed distance to the DGR by road	1,000 km	1,000 km
Total number of shipments over the project duration	124	124
Duration of shipments	Years 41-51	Years 41-51
Reactor site production to occur in parallel with shipments to the DGR?	No	No

An important assumption for the Douglas Point site is that used fuel will be shuttled to the Bruce shipping and receiving facility for transfer into IFTCs and shipment to the DGR.

A.5 AECL's Chalk River Laboratories Site

Chalk River Laboratories (CRL) is a nuclear research establishment with a number of test reactors, fuel inspection and other facilities. The site covers approximately 37 km^2 and is a two hour drive northwest of Ottawa. Following the 1987 termination of operations at the Nuclear Power Demonstration (NPD) reactor at Rolphton, the NPD reactor was de-fuelled and the used fuel was shipped to the CRL for storage. Previous shipments of NPD used fuel had also been stored here. Note that the site also stores a quantity of research reactor fuels of various types and configurations that are not included in the scope of this study.



The following provides the important Chalk River site parameters relevant to the UFTS.

Parameter	Base Case	Alternate Case
Assumed distance to the DGR by road	1,000 km	1,000 km
Total number of shipments over the project duration	27	27
Duration of shipments	Years 52-55	Years 51-55
Reactor site production to occur in parallel with shipments to the DGR?	No	No

A.6 AECL's Whiteshell Laboratories

The Whiteshell Laboratories are situated in southeastern Manitoba. In 1974, the Whiteshell Laboratories conducted a program to demonstrate the viability of above-ground dry storage of used/spent fuel. Two dry storage containers each with a different shape were demonstrated. The first was a cylindrical canister similar to the storage system employed at Point Lepreau. The second comprised an octagonal canister as used to store the square baskets containing Douglas Point used fuel. Note that the site also stores a quantity of research reactor fuels of various types and configurations that are not included in the scope of this study.

The site is not currently producing or projected to produce more used fuel.



The following lists the important Whiteshell site parameters relevant to the UFTS.

Parameter	Base Case	Alternate Case
Assumed distance to the DGR by road	1,000 km	1,000 km
Total number of shipments over the project duration	2	2
Duration of shipments	Year 51	Year 51
Reactor site production to occur in parallel with shipments to the DGR?	No	No

A.7 Gentilly Site

The Gentilly facility is situated on the banks of the Saint Lawrence River. The site, generally flat and open, is 15 km from the Town of Trois-Rivières and is owned and operated by Hydro-Québec. The site houses two reactors, Gentilly 1, owned by AECL, and Hydro-Québec's Gentilly 2.

A.7.1 AECL's Gentilly 1

The Gentilly 1 reactor has been de-fuelled and is no longer operational. The used fuel is currently held within 85 baskets, which in turn are stored within an array of silos inside a turbine building.



The following table lists the important Gentilly 1 site parameters relevant to the UFTS.

Parameter	Base Case	Alternate Case
Assumed distance to the DGR by road	1,500 km	1,500 km
Total number of shipments over the project duration	18	18
Duration of shipments	Years 52-55	Years 51-55
Reactor site production to occur in parallel with shipments to the DGR?	No	No
Distance to Ontario border along major highways (see Note)	274 km	274 km

A.7.2 HQ's Gentilly 2

The Gentilly 2 Nuclear Generating Station's used fuel is stored in the station's wet bay and within concrete vaults. Each vault is designed to hold 200 baskets with baskets stored in 20 liners (10 baskets per vault liner).



The following table provides the important Gentilly 2 site parameters relevant to the UFTS.

Parameter	Base Case	Alternate Case
Assumed distance to the DGR by road	1,500 km	1,500 km
Total number of shipments over the project duration	697	1,417
Duration of shipments	Years 41-55	Years 41-72
Reactor site production to occur in parallel with shipments to the DGR?	No	Yes
Distance to Ontario border along major highways (see Note)	274 km	274 km

In the Alternate Case, the continued use of the Gentilly 2 reactor in parallel with shipments to the DGR is assumed not to affect the availability of on-site shipping facilities.

A.8 NBP's Point Lepreau Site

The Point Lepreau Generating Station is owned and operated by New Brunswick Power, which is charged with the responsibility for generating and distributing electrical power within the Province of New Brunswick. The station is located on the Bay of Fundy, approximately 40 km west of Saint John and 45 km from the border between Maine (USA) and New Brunswick. The Point Lepreau Nuclear Generating Station is located on the site and all used fuel produced by the station is stored in the station's wet bay and silos.



The following lists the important Point Lepreau site parameters relevant to the UFTS.

Parameter	Base Case	Alternate Case
Assumed distance to the DGR by road	2,500 km	2,500 km
Total number of shipments over the project duration	636	1,486
Duration of shipments	Years 41-55	Years 41-74
Reactor site production to occur in parallel with shipments to the DGR?	No	Yes
Distance to Ontario border along major highways (see Note)	1,061 km	1,061 km

In the Alternate Case, the continued use of the Point Lepreau reactor in parallel with shipments to the DGR is assumed not to affect the availability of on-site shipping facilities.

A.9 New Build A and New Build B Sites

The New Build A and New Build B reactors are assumed to be based on existing reactor designs and located somewhere in Ontario. A conceptual illustration of the new build sites are shown below.



For the Alternate Case, it is assumed that the New Build A and New Build B facilities for shipping, receiving and storing IFTCs and used fuel transportation vehicles and equipment will be available similar to the current OPG Darlington site. The following lists the important new build site parameters relevant to the UFTS.

For the New Build A reactor site:

Parameter	Base Case	Alternate Case
Assumed distance to the DGR by road	N/A	1,000 km
Total number of shipments over the project duration	0	4,208
Duration of shipments	N/A	Years 67-85
Reactor site production to occur in parallel with shipments to the DGR?	N/A	No

For the New Build B reactor site:

Parameter	Base Case	Alternate Case
Assumed distance to the DGR by road	N/A	1,000 km
Total number of shipments over the project duration	0	4,435
Duration of shipments	N/A	Years 66-85
Reactor site production to occur in parallel with shipments to the DGR?	N/A	No